J. L. R. HAYDEN.

VAPOR RECTIFIER FOR HIGH POTENTIAL CIRCUITS.

APPLICATION FILED OCT. 25, 1905.

1,076,884.

Patented Oct. 28, 1913.

2 SHEETS—SHEET 1.

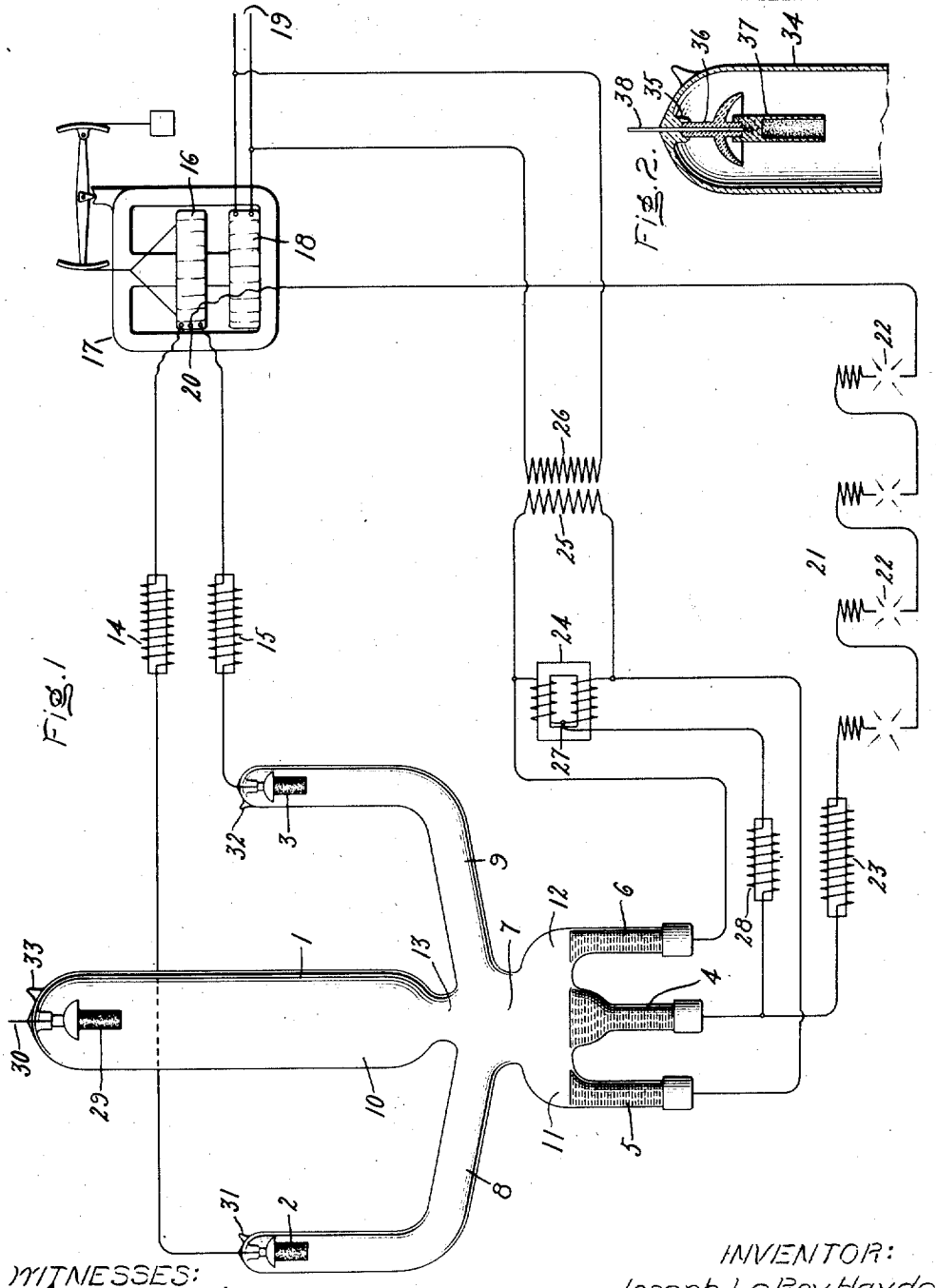


Fig. 1.

Fig. 2.

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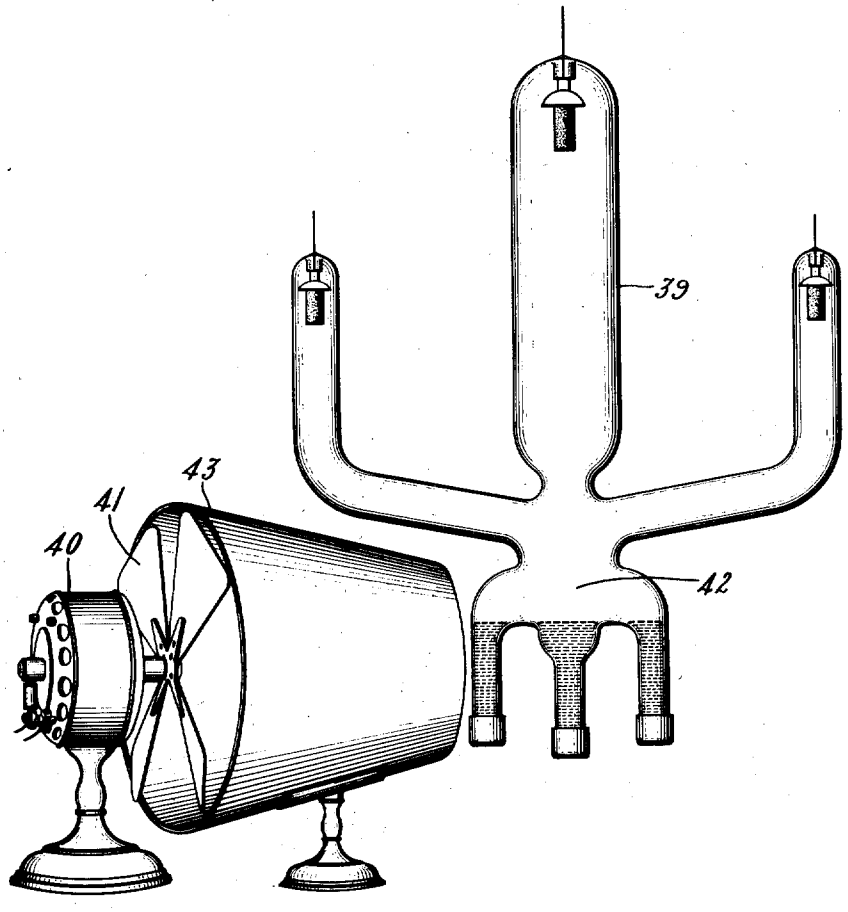
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2 SHEETS—SHEET 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

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VAPOR-RECTIFIER FOR HIGH-POTENTIAL CIRCUITS.

1,076,884. Specification of Letters Patent. Patented Oct. 28, 1913.

Application filed October 25, 1905. Serial No. 284,333.

To all whom it may concern:

Be it known that I, JOSEPH LE ROY HAYDEN, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Vapor-Rectifiers for High-Potential Circuits, of which the following is a specification.

This invention relates to vapor electric devices and more particularly to vapor rectifiers for use on high-potential circuits, such for instance, as are employed in operating constant current arc lamps.

For many reasons it is desirable to use high voltages for series arc lamp circuits and when a rectifier is used to supply current to such circuits it is subjected to an exceedingly high potential between anodes.

My present invention relates to an improved form of rectifier tube adapted for the use above mentioned and capable of operating on potentials of many thousand volts.

My invention also relates to an improved means for producing condensation in the rectifier tube and for governing the condensing action of different parts of the tube.

When vapor rectifiers are operated on high-potential circuits they are sometimes subject to a phenomenon, which I prefer to designate by the term "arcing", which is liable to completely destroy the rectifier, or at least to so impair the vacuum as to cause a rapid deterioration of the tube. When arcing takes place one of the electrodes which normally operates as anode becomes for the time being a cathode. This may occur during but a single half period, or may last for several successive half waves of current. In either case it is likely to be detrimental to the tube. Arcing may result from the engagement of mercury with the solid anodes or with the leading-in wires by which connection is made between the anodes and the external circuit, and my present invention provides means whereby contact of mercury with the anodes or with the leading-in conductors is entirely prevented. The contact of mercury with the anodes may result from several causes, such for instance, as spattering or mechanical projection from the cathode surface by the high velocity blast which issues from that surface when the rectifier is working under normal conditions. It may also be due to condensation of the mercury on the anode or in the space above the anode which of course can only occur when those parts of the tube are cool enough to cause condensation; this I avoid in my present form of tube by directing a fan blast against the cathode chamber and deflecting the blast from the anode tubes so that the anode tubes operate at a temperature somewhat higher than other parts of the envelop. This local condensation produced by the fan blast is supplemented by the natural condensing or heat radiating power of the various parts of the tube. The tube is so designed that the anode chambers are of relatively small cross section and have only a small space above the anodes in which condensation could possibly take place. There is of course a limit to the operating temperature of the anodes for if they are heated too hot there is the possibility of an arc springing from one anode to the other carried by material vaporized directly from the anodes, but as I prefer to use carbon or graphite as an anode material there is a considerable range of working temperatures below that at which carbon vaporizes and consequently below that at which a carbon arc would form.

In the drawing, Figure 1 shows my improved form of rectifier tube properly connected for supplying direct current to a constant current series arc circuit, and receiving energy from a movable coil transformer of ordinary type energized from a constant potential source; Fig. 2 is a sectional view showing the details of my improved form of anode connection; and Fig. 3 shows the location and arrangement of the cooling fan.

The rectifier tube 1 is provided with a plurality of graphite anodes 2 and 3 and a mercury cathode 4. Auxiliary anodes 5 and 6 are also provided adjacent to the mercury cathode 4, and are utilized for starting the rectifier into operation, or for assisting in maintaining the rectifier continuously conductive for current from the anodes 2 and 3 to the mercury cathode 4. Immediately above the mercury cathode 4 is an irregular shaped chamber 7 which I prefer to desig-

nate as the cathode chamber. Opening into this chamber are two anode tubes 8 and 9, and a condensing chamber 10, and also two curved passages 11 and 12 leading to the auxiliary anodes 5 and 6. The anode chambers 8 and 9 slope upward and outward from the cathode chamber and at a point about midway of their length have relatively sharp bends and then extend directly upward to their respective anodes 2 and 3. These anodes are located near the ends of the anode tubes so that there is practically no dead space above the anodes in which mercury could condense and from which it might fall on the anodes and cause arcing as heretofore pointed out. The condensing chamber 10 opens into the cathode chamber 7 through a constricted orifice 13, the walls of which form a baffle surface for the high velocity blast issuing from the cathode and serve not only to deflect back to the cathode chamber a large part of the excess mercury carried by the cathode blast, but also operate to equalize the vapor pressure in the two anode chambers and thus prevent the rectifier from being extinguished, even when it is subjected to severe working conditions such as may result from a defective arc lamp in the load, or a defect in the reactances or transformer connected with the rectifier.

In order that my invention may be better understood I have shown my improved form of rectifier tube connected up in an operative manner, though it should be understood that vapor tubes of this form may be advantageously used for a great variety of work. In the system which I have chosen to illustrate the advantages of my improved rectifier tube, the anodes 2 and 3 are connected through reactances 14 and 15 to the secondary 16 of a transformer 17, the primary 18 of which receives energy from the constant potential alternating current source 19. This transformer is of a general type well known in the electrical arts, and is adapted to effect a regulation of the secondary current by automatic relative movement of the coils to vary the distance between the primary and secondary and consequently to vary the inductive effect of one on the other. The secondary 16 is provided with a central tap 20 connected directly to one side of the series consumption circuit 21 which may contain a plurality of translating devices 22 such as mercury arc lamps, magnetite arc lamps, motors or other devices capable of successful operation on a series circuit. The cathode 4 of the rectifier is connected to the other end of this consumption circuit through a reactance 23. This reactance serves not only to smooth out irregularities in the current delivered by the rectifier, but also operates in conjunction with reactances 14 and 15 to maintain a continuous flow of current through the rectifier 1, which flow of current has been found necessary to prevent the rectifier from going out at the so-called dead points of the current wave, or, in other words, at the points where the polarity of the source reverses sign. These reactances are operative in producing this continuous flow of current in the rectifier tube by causing an overlapping of the current waves supplied by the anodes so that current begins to flow from one anode before it ceases flowing from the other. The auxiliary anodes 5 and 6 are connected to the terminals of a reactance 24, and also to the terminals of a transformer secondary 25 energized by a primary 26 connected to the constant potential source 19. Reactance 24 is provided with a neutral point 27 connected through a reactance 28 with mercury cathode 4.

In starting the rectifier into operation the tube is tilted or shaken to establish a momentary contact between mercury cathode 4 and one of the auxiliary anodes 5 or 6, which momentary contact serves to draw an arc in the lower part of the rectifier tube, and thus start the rectifier into operation in a manner well known to persons skilled in the art. Reactances 24 and 28 serve to produce an overlapping of the currents delivered by anodes 5 and 6, so that this exciting circuit is self-maintaining and operates to maintain current flow to cathode 4 irrespective of the condition or resistance of the consumption circuit 21. After the rectifier has once been started this exciting circuit may be disconnected from the tube as the rectifier when provided with reactances 14, 15 and 23 is entirely capable of maintaining itself continuously conductive. For certain purposes, however, I find it often desirable to leave the exciting circuit connected to the tube which arrangement, of course, has the disadvantage of utilizing a certain quantity of energy, but which has the advantage of permitting the rectifier to bridge over interruptions, variations or violent fluctuations in the consumption circuit with a consequent gain in the reliability of the system.

When the rectifier tube is operating under normal conditions current waves are delivered alternately from the anodes 2 and 3 to the mercury cathode 4, and cause the projection of the cathode blast, the direction of which is in general normally to the surface of the mercury. This cathode blast issues from a cathode spot of relatively limited area which wanders about in a more or less erratic way over the surface of the mercury cathode. This cathode spot is the seat of a relatively large vaporization of mercury, from heat as well as from the direct projection by the current, so that the arc

stream which leaves the cathode carries with it a large quantity of excess mercury, which if permitted to impinge on the anodes is likely to cause the "arcing" or "striking back" previously mentioned. In my improved form of rectifier tube this cathode blast impinges against the edges or walls of the constricted opening to the condensing chamber so that a considerable quantity of the excess of mercury is deflected back into the cathode chamber; the walls acting somewhat like baffle plates to turn the mercury back. The excess mercury which escapes through the opening 13 into the chamber 10 is there condensed on the walls of the chamber and trickles down and is ultimately returned to the cathode 4. It will be noted that the part of the cathode blast which passes through the anode tubes to the anodes changes its direction abruptly as it leaves the cathode chamber thus tending to leave behind any mechanically-suspended mercury. The proportion of excess mercury is further reduced by the second bend given the arc by the sharp angles in the anode tubes themselves, and any excess mercury which reaches these bends is deposited on the walls of the tubes and trickles down toward the cathode chamber.

My invention embodies improved means for returning condensed mercury to the cathode chamber, which feature I consider of importance as it obviates some of the difficulties which have heretofore been encountered in the operation of rectifiers. Condensed mercury trickling down the anode tubes 8 and 9 is caught in the cups of auxiliary anode 5 and 6, and from time to time overflows into the cathode chamber 4, and thus replenishes the chamber to compensate for the material which is continuously evaporated from this electrode. It will be understood that when the rectifier is normally operating the level of cathode 4 may be somewhat lower than shown in the drawing because of the vaporization by the arcs. I consider it of importance to have the anodes overflow into the cathode, and not to permit the cathode to overflow into the anode, for if the latter action should occur there is a possibility that the cathode spot will move over with the overflow, and thus introduce a part of the exciting circuit in series with the load, consequently unbalancing the system, and possibly endanger various parts of the apparatus. As will be seen from the drawing, the rectifier tubes 8 and 9 are of practically the same cross-section throughout their entire length which construction I have found gives the rectifier steadiness and reliability for high-voltage work.

In operating rectifiers on high voltages it is exceedingly important to have the rectifier properly exhausted, and to prevent the formation of gas or other foreign vaporous material in the rectifier tube. Not only must the space in the tube be completely exhausted, but the anodes and even the mercury in the cathode must be suitably treated to remove occluded gases which might subsequently be freed and impair the vacuum in the tube.

I find that gases or other foreign material liberated by the anodes when hot are readily absorbed again by the anodes when cold, and I make use of this fact by providing the rectifier with a supplemental anode 29 which under normal conditions is not connected with any of the circuits, and which operates principally as an absorbent for gases or other volatile material given off or produced in any way within the tube. I locate this supplemental anode in the condensing chamber 10, as I find when so located it will absorb enormous quantities of gas or other impurities, and thus permit the rectifier to operate at voltages and under conditions which would be entirely impracticable for rectifiers not provided with this absorbing means. While I do not wish to be limited as to any particular theory of operation for this supplemental anode when located at the end of the condensing chamber as shown in the drawing it appears possible that the high velocity blast issuing from the cathode exerts a sort of bombarding action on the molecules of foreign gas in the lower part of the tube, and thereby projects them upward toward the end of the condensing chamber where they are absorbed by the supplemental anode 29. Whatever may be the principle which underlies the action of this absorbing anode, I find that it is a valuable adjunct to mercury rectifiers operating on high voltages.

I prefer to provide the supplemental anode 29 with the leading-in conductor 30 so that the anode can be connected to a source of current and be used to maintain an arc with the mercury cathode 4. This feature is of particular advantage in the manufacture or repair of the tube, as it is desirable when exhausting the envelop to heat up all three anodes at the same time by maintaining continuous current arcs between them and the common cathode. These arcs serve to heat up the anodes and all parts of the tube and thus drive out gases or other impurities from the anodes which gases may be removed from the tube by a suitable pump. In pumping out the tube I prefer to exhaust simultaneously from both anode tubes and condensing chamber at the points 31, 32 and 33, as I find that when the tubes are so exhausted they have a vacuum well suited for high voltage work.

The dielectic strain on the insulation of

the leading-in wires of the anode is so exceedingly severe for potentials such as are commercially desirable for series circuits that special precautions are necessary to prevent the rectifier from arcing across from one anode to the lead-wire of the other anode, and my present invention contemplates a means for obviating this difficulty. The danger of arcing is of course greatly enhanced if the lead-wire is at any point exposed to the mercury vapor, as it might thereby become amalgamated and furnish a ready seat for a transitory cathode. Fig. 2 shows the details of the anode connection which I find affords proper protection to the anode and anode lead. The anode tube 34 has an inwardly-projecting lug 35 of glass in which is embodied one end of a lava sleeve 36 on which the anode 37 is mounted. A platinum lead-wire 38 is sealed in the glass 35 and screw-threaded into the upper end of the anode 37. The anode 37 is in the form of a hollow cylinder with one closed end, and it is into this closed end that the platinum wire is screw-threaded. It is preferable to make the anode hollow so that there may be a relatively large surface for the mercury arc, and also that all parts of the anode material may be near the surface so that occluded gases may be readily drawn through the pores of the material during the manufacture of the lamp.

As I have previously stated, it is very desirable to protect the platinum lead-wire from contact with the mercury vapor, and consequently the screw-threaded hole in which the lead-wire fits does not extend entirely through the end wall of the anode, and consequently does not expose the end of the lead-wire to the mercury arc. The sleeve 36 carries an umbrella-shaped shield which projects outwardly and downwardly below the top of the anode and serves not only to protect the anode from mercury or other matter falling from the top of the anode chamber, but also serves to shield the upper part of the anode from the mercury arc and thereby prevents the possibility of the arc puncturing through the joint between the anode and the insulating sleeve. This shielding action is in the nature of a throttling of the arc from the upper part of the anode, which effect is possibly produced because of the comparatively confined space under the shield as compared with other parts of the surrounding space.

Fig. 3 shows a rectifier tube 39 equipped with a fan motor 40 driven by any suitable source of energy. This motor operates a fan 41 to direct a blast of air against the cathode chamber 42 of the rectifier tube. A metal shield 43 serves to concentrate the air blast on the cathode chamber of the rectifier and at the same time to shield the anode tubes from this cooling blast. By the use of this blast on the cathode and cathode chamber, these parts are kept relatively cool and not only is the total vaporization cut down, but the proportion of vapor which passes upward through the anode tubes is materially diminished.

While I have shown the application of the cooling air blast to a rectifier of a specific type it will be understood that my invention is not limited to this particular application.

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

1. A vapor electric apparatus having a vaporizable cathode, a cathode chamber adjacent thereto, a condensing chamber having a constricted opening, a plurality of anode tubes opening into said cathode chamber and having a substantially uniform cross-section throughout their entire length, an anode near the end of each of said tubes, said anode tubes having bends to protect said anodes from liquid mercury.

2. A vapor electric apparatus comprising an evacuated envelop containing a vaporizable cathode, means for passing current through said apparatus to said cathode, a condensing chamber operatively related to said cathode, and a body of gas-absorbing material in said condensing chamber.

3. A vapor electric apparatus comprising an evacuated envelop containing a vaporizable cathode, means for passing current through said apparatus to said cathode, a condensing chamber operatively related to said cathode, continuously operative gas-absorbing means in said condensing chamber, and means for electrically heating said gas-absorbing means to liberate absorbed gases.

4. A vapor electric apparatus comprising an evacuated envelop containing a vaporizable cathode, means for passing current through said apparatus to said cathode, a condensing chamber operatively related to said cathode, gas-absorbing means in said condensing chamber, and means for conducting current through said apparatus from said gas-absorbing means to said vaporizable cathode.

5. A vapor electric apparatus comprising an evacuated envelop containing a vaporizable cathode and a solid anode, a condensing chamber operatively related to said cathode, and a supplemental anode of graphite in said condensing chamber, normally disconnected from the source of current and operating to absorb foreign matter in said tube.

6. A alternating current vapor electric apparatus having an anode tube, an anode near the upper end of said tube, and an umbrella-shaped shield of inert, refractory material above said anode and located between the anode and the glass which sur-

rounds the leading-in wire leaving said anode unconfined, said shield being so disposed with respect to the anode as to throttle the arc from one end thereof.

7. In an alternating-current vapor electric apparatus, an evacuated envelop, a solid anode mounted near the wall of said envelop, a lead-wire connected to said anode, and an outwardly-extending flange on said lead-wire between the anode and said envelop, leaving said anode unconfined but constricting the space above said anode.

8. In an alternating current electrical apparatus, an evacuated envelop, an anode mounted therein, a bushing separating said anode from said envelop, and an umbrella-shaped flange on said bushing extending downward to inclose the upper end only of said anode.

9. The combination in a vapor electric apparatus, of an exhausted envelop or receptacle, a plurality of anodes therein and also a vaporizable cathode, and means for directing a cooling fluid against the receptacle in the region of the cathode but away from the anodes.

10. The combination of a vapor electric apparatus having an evacuated envelop and a vaporizable cathode, means for directing an air blast against said envelop in the region of said cathode and means for shielding said blast from other parts of said vapor apparatus.

11. The method of decreasing the arcing between the positive electrodes of a mercury vapor device containing a plurality of positive electrodes, which consists in maintaining the environment of said positive electrodes at a relatively higher temperature than the environment of the negative electrode.

12. The method of decreasing the arcing between the anodes of a mercury vapor rectifier, which consists in locally cooling the cathode of said rectifier.

13. The combination of a vapor electrical apparatus having a plurality of anodes subject to differences of potential and a vaporizable cathode and cooling means for the apparatus confined in its effect to the region of the cathode whereby the proportion of the vapor near the anodes is diminished.

14. The combination of an evacuated envelop, a vaporizable cathode and a plurality of solid anodes therein subject to differences of potential and means for delivering a cooling fluid locally in the neighborhood of the cathode but away from the anodes whereby the presence of vapor in the environment of the anodes is decreased by the resulting differences of temperature.

15. A vapor rectifier having a vaporizable cathode, a cathode chamber above the same having a constricted opening, a plurality of separate tubes extending outwardly from said opening each having an upward bend, and an anode for each tube mounted beyond the bend thereof said anodes alternating in potential.

16. A vapor rectifier having a vaporizable cathode, a cathode chamber above the same having a constricted opening, a baffle surface above said opening, a plurality of separate closed tubes extending outwardly from said opening each having a bend therein, and a solid anode for each tube mounted beyond the bend thereof and near the closed end of the tube.

17. A vapor rectifier having a vaporizable cathode, a cathode chamber surrounding the same, a baffle surface above said cathode, a plurality of arc tubes opening into said chamber and extending outward therefrom, bends in said arc tubes, and solid anodes located beyond said bends and alternating in potential.

18. A vapor electric apparatus having a cathode and a plurality of solid anodes, separate tubes for said anodes, and a condensing chamber located above said cathode and having its lower end constricted to throttle the cathode blast as it enters the condensing chamber.

19. A vapor electric apparatus having a vaporizable cathode and a plurality of solid anodes, separate tubes for said anodes each extending outward and having a relatively sharp bend, and a condensing chamber for receiving the direct blast from said cathode having its lower end constricted to throttle said blast as it enters the condensing chamber.

20. A vapor electric apparatus having a vaporizing cathode, and a plurality of solid anodes, separate tubes for said anodes each extending outward and having a relatively sharp bend, said tubes being of substantially the same cross-section throughout their entire length and a condensing chamber for receiving the cathode blast having its lower end constricted to throttle said blast as it enters the condensing chamber.

21. A vapor electric apparatus having a vaporizable cathode, a cathode chamber therefor, a plurality of anode tubes, each tube communicating at one end with the cathode chamber but having the other end closed and out of direct communication with any other anode tube, anodes mounted near the closed ends of said tubes, said anode tubes having bends to shield the anodes from the direct action of the cathode blast and having vertical portions in which the anodes are mounted.

22. A vapor electric apparatus having a vaporizable cathode, a cathode chamber adjacent thereto, a condensing chamber communicating with said cathode chamber

through a constricted orifice, a plurality of anode tubes opening into said cathode chamber, an anode in each of said tubes, said anode tubes having bends to protect said anodes from the direct action of the cathode blast.

In witness whereof I have hereunto set my hand this 23rd day of October, 1905.

JOSEPH L. R. HAYDEN.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.

Correction in Letters Patent No. 1,076,884.

It is hereby certified that in Letters Patent No. 1,076,884, granted October 28, 1913, upon the application of Joseph L. R. Hayden, of Schenectady, New York, for an improvement in "Vapor-Rectifiers for High-Potential Circuits," an error appears in the printed specification requiring correction as follows: Page 5, line 104, for the word "vaporizing" read *vaporizable;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of November, A. D., 1913.

[SEAL.]

R. T. FRAZIER,
Acting Commissioner of Patents.

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