

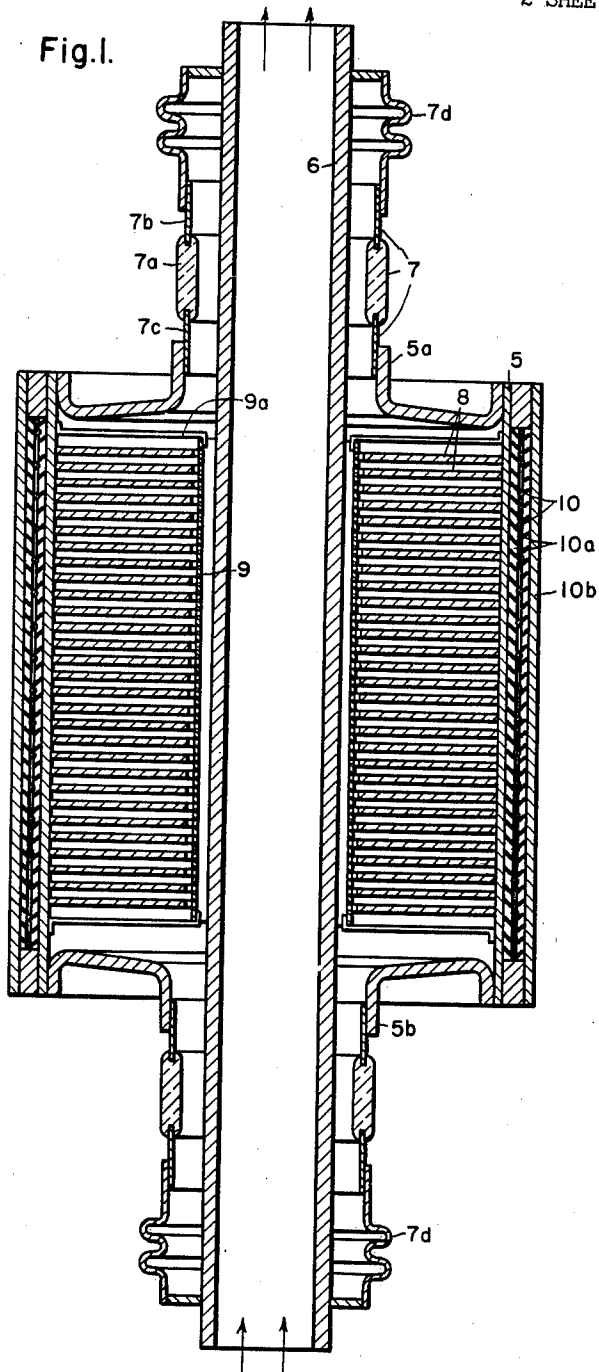
May 5, 1953

J. L. BOYER ET AL
ALKALI-METAL RECTIFIER

2,637,827

Filed March 30, 1951

2 SHEETS—SHEET 1



WITNESSES:

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2 SHEETS—SHEET 2

Fig. 2.

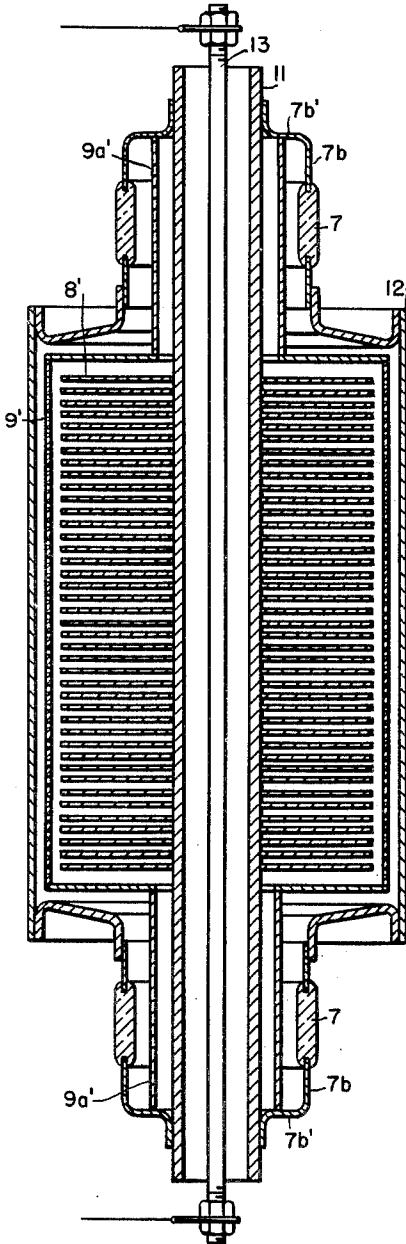
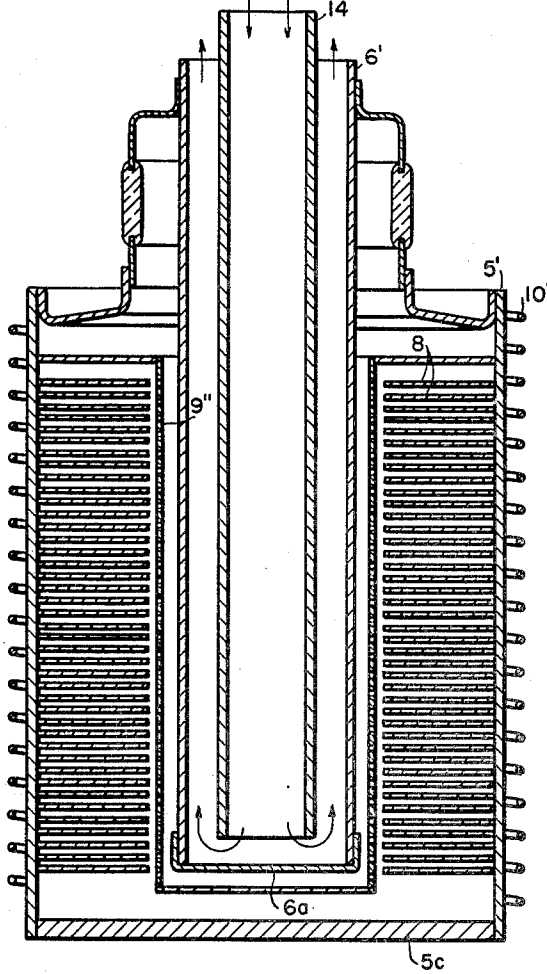


Fig. 3.



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2,637,827

ALKALI-METAL RECTIFIER

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16 Claims. (Cl. 313—30)

1

Our invention relates to vapor-electric devices or tubes, and particularly to an improvement over the general class of hot-cathode arc-discharge devices using a vaporizable discharge-metal selected from the alkali-metal group consisting of cesium, rubidium and potassium, as described and claimed in a copending application of John L. Boyer and August P. Colaiaco, Serial No. 144,354, filed February 15, 1950. As explained in the first paragraph of said copending application, these three alkali-metals, cesium, rubidium and potassium, 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 structures, or the stable alkali-metals having more than three shells in their atomic structures.

One of the basic ideas of our present invention is a reversal of the heretofore-known positions of the anode and cathode in a hot-cathode alkali-metal tube. In other words, we place the heated cathode on the outside, and use an anode in the form of a tube extending axially with respect to the tube on the inside. Preferably, although not necessarily, our internal-anode tube is a through-tube, as distinguished from a re-entrant tube having a closed inner end. As a corollary to this thought, our invention also involves the broad idea of any through-tube construction, for the inner electrode of a concentric-electric tube (particularly, for a tube of the hot-cathode alkali-metal type), whether the inner electrode is an anode or a cathode.

A characteristic feature of a hot-cathode alkali-metal tube is that the cathode shall be formed on a metal cathode-tube which is heated by means of a suitable heat-source, and the active cathode-surface shall be comprised of a large number of metal cathode-fins which are in good thermal and electrical contact with the heated cathode-tube. These cathode-fins must be operated at a temperature somewhere in the vicinity of 700° C. The anode, on the other hand, must be cooled to a temperature of the order of 250° C. Between the anode and the cathode, the evacuated container of the tube contains an insulating seal or seals, which ought to be maintained at a temperature which is not nearly as hot as the cathode temperature, but which also must not be as cold as the coldest surface which is maintained within the container, so that the metal-vapor will not condense on the insulator and provide an electrical short-circuit thereacross.

An advantage of the external-cathode form of construction is that the cathode-fins will provide a greater electron-emitting area for the same overall size or diameter of rectifier-tube, because the cathode-fins of an external-cathode tube will have a larger diameter than in an internal-cathode tube. The external-cathode construc-

2

tion is advantageous also in having its cathode-heater on the outside of the rectifying-device, where it is easy of access, larger in heating-area than an internal heater, and susceptible of a convenient sectionalized construction for obtaining excellent temperature-control of the cathode.

A general advantage of the type of rectifier-tube construction, having a through-type internal or inside tubular electrode, is that a stream of a temperature-controlling heat-exchange fluid may be passed lengthwise all the way through the inside tube, thus conveniently and accurately controlling its temperature. When this inside tube is an anode, which has to be cooled, the stream of cooling-fluid thus comes into contact only with the anode-tube, and does not play directly on the insulating-seals which are provided in a position in which they surround, and are spaced radially from, the open ends of the inside tube, so as not to be directly contacted by the moving cooling-fluid which passes through the inside tube.

With the object of obtaining the above-described, and other, structural advantages in mind, our invention consists in the shapes, structures, arrangements, combinations, parts, systems, and methods of design and operation hereinafter described and claimed, and illustrated in the accompanying drawing, wherein the three figures are vertical sectional views showing three different illustrative forms of embodiment of our present invention.

In the form of invention which is shown in Fig. 1, we show a hot-cathode alkali-metal rectifier-tube in the form of a vapor-electric device comprising an evacuated enclosure-means which is composed essentially of two main metallic parts, which are joined by two insulating seals. The central portion of the enclosure is an enlarged metal cylindrical member which is used as a cathode-tube 5, and which is provided with suitable end-portions 5a and 5b. The cathode-tube 5 thus constitutes the other cylindrical wall of the rectifier-container or enclosure. Extending longitudinally or axially through the assembly, and for some distance beyond each end of the cathode-tube 5, is a relatively small-diameter tube 6, which serves as the anode of the device, in the particular form which is illustrated in Fig. 1. Surrounding, and spaced radially from, each of the projecting ends of the anode-tube 6 is a cylindrical insulator-seal 7 which makes a vacuum-tight connection between the corresponding ends of the anode and cathode-tubes 6 and 5. Each insulator seal 7 may comprise a tubular glass member 7a and two metal spinnings 7b and 7c, which are pressed into the respective ends of the glass cylinder 7a, and which are suitably welded or brazed to metal parts which in

turn complete the vacuum-tight connection between the two main tubular members 6 and 5, respectively.

Since there must be, somewhere in the container, a part which is longitudinally flexible enough to allow for the unequal thermal expansions of the unequally heated tubular portions 5 and 6, one means for obtaining this flexibility is shown in Fig. 1, in the form of a flexible bellows 7d at each end of the container. By controlling the compression of the bellows in the construction of the tube, a known compression-force can be initially placed on the two glass bushings 7.

As is common in hot-cathode alkali-metal tubes, the tube-enclosure contains a small quantity of a discharge-metal selected from the group comprising cesium, rubidium and potassium; and the heated tubular cathode-member 5 is provided with a large number of metal cathode-fins 8, which are shown, in Fig. 1, in the form of washers which project in toward the anode-tube 6. The outer peripheries of the cathode-fins 8 are secured in good thermal, electrical and mechanical connection to the inner periphery of the cathode-tube 5; while the bores of the washer-like cathode-fins 8 are radially spaced from the anode-tubes 6.

It is also usually desirable to protect the heated cathode-fins 8 against undue heat-loss, as by the interposition of a perforated cylindrical heat-shield 9, which may be of thin sheet-metal, and which is mechanically supported so as to be in poor thermal relation to one of the container-parts, such as the cathode-tube 5, as described and claimed in the previously mentioned application of Boyer and Colaiaco. As shown in Fig. 1, the heat-shield 9 is supported by means of wires 9a.

The interior through-tube 6 which constitutes the anode in Fig. 1 is cooled by any suitable means, such as by a fluid-stream which passes all the way through the tube, as indicated by the arrows in Fig. 1. These arrows are intended to be symbolic of any means for causing the passage of cooling-air, or other cooling-fluid, through the anode-tube 6, either by reason of a natural or gravitationally induced fluid-flow, or by means of suitable pumps or blowers (not shown).

The exterior cathode-tube 5, in Fig. 1, is heated by any suitable means, illustrated in the form of a heater-coil 10 which is disposed around the cathode-cylinder 5, being spaced therefrom and supported by suitably notched, vertically supported, insulator-strips 10a. If desired, the heater 10 may be enclosed within an evacuated enclosure 10b for prolonging the life of the heater.

In Fig. 2, we show a rectifier-tube construction in which the relative positions of the anode and cathode are reversed from the arrangement shown in Fig. 1, being here shown in the conventional arrangement in which the heated cathode is on the inside and is surrounded by a cooled anode which constitutes part of the cylindrical outer walls of the evacuated container.

The Fig. 2 construction differs from the previously known constructions of a hot-cathode alkali-metal tubes, however, in having a cathode-tube which is in the form of an inner through-tube 11 which extends all the way through the device, in a manner similar to the through-tube anode-member 6 in Fig. 1. The outer cylindrical wall-portion 12 of the Fig. 2 construction constitutes the anode of the device. The insulating seals 7 of Fig. 1 are also used in Fig. 2, with the

exception that the metal spinnings 7b at the respective ends of the device have bent-over flexible-disc portions 7b' which will provide the necessary axial flexibility for taking care of thermal expansions and contractions.

In the Fig. 2 rectifier-tube, the external anode-cylinder 12 is cooled by direct exposure to the ambient atmosphere, and the inner through-tube 11 of the cathode is heated, either by means of a fluid-stream passing through it after the manner of Fig. 1, or by means of an interiorly disposed heater, which is illustrated in the form of a resistance-bar 13 which extends all the way through the inner tube 11, and which is heated by passing a heating-current through it. The cathode-fins 8', in Fig. 2, are thermally secured, at their bores, to the heated cathode-tube 11, and these cathode-fins are protected against undue heat-loss by a perforated heat-shield 9', which may be supported from cylindrical end members 9a' from the metal spinnings 7b or any other convenient portion of the device, preferably at approximately the cathode-potential.

In Fig. 3, we show a form of rectifier-tube construction having an external cathode, similar to Fig. 1, except that the internal anode-tube 6', in Fig. 3, is not a through-tube, as in Fig. 1, but is a re-entrant tube, which extends into the device from only one end. The re-entrant anode-tube 6' in Fig. 3 has a closed inner end 6a. The outer cathode-tube 5', in Fig. 3, has a closed end 5c, which is spaced from the closed anode-end 6a. The cathode-fins 8 of Fig. 3 are disposed as shown and described in connection with Fig. 1. The perforated heat-shield 9'' of Fig. 3 is shown in the form of a cup-shaped member which extends in spaced relation around the closed inner end of the anode-tube 6'. The outer cathode-tube 5' of Fig. 3 is heated by any suitable means, such as a diagrammatically indicated heater 10'; while the interiorly disposed re-entrant anode-tube 6' in Fig. 3 is diagrammatically indicated as being cooled by a stream of cooling-air which enters through a duct or baffle 14, and leaves again, from the same open end of the anode-tube 6', as indicated by the arrows.

While we have illustrated our invention in only three exemplary forms of embodiment, we wish it to be understood that we are not limited to these precise details, and we desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

We claim as our invention:

1. A vapor-electric device comprising an evacuated enclosure-means, an anode, a cathode, and a quantity of a discharge-metal within the device, said discharge-metal being selected from the group consisting of cesium, rubidium, and potassium; said cathode including a metal tube-portion constituting side-walls of said enclosure-means, said metal tube-portion of said cathode carrying interiorly extending cathode-fins in good thermal and electrical contact therewith; said anode including a metal tube-portion extending interiorly of said enclosure-means and inside of said finned portion of the cathode; said enclosure-means including an insulating seal-means between said cathode and said anode; means for heating the outside of the metal tube-portion of said cathode; and means for cooling the inside of the metal tube-portion of said anode.

2. The invention as defined in claim 1, characterized by said anode tube-portion being a re-entrant tube, closed at its inner end; said

5

cooling means comprising means for causing a cooling-fluid to enter said re-entrant tube through its open end to circulate through said re-entrant tube, and to leave it again through said open end; and said insulating seal-means being disposed between said open end of the re-entrant anode-tube and the corresponding end of the cathode tube-portion, said insulating seal-means surrounding, and being spaced radially from, said open end of the re-entrant anode-tube, so as not to be directly contacted by said moving cooling-fluid which circulates in said anode-tube.

3. A vapor-electric device comprising an evacuated enclosure-means, an anode and a cathode constituting the two main electrodes of the device, and a quantity of a discharge-metal within the device, said discharge-metal being selected from the group consisting of cesium, rubidium and potassium; one of said main electrodes including an outer metal tube-portion constituting side-walls of said enclosure-means; the other main electrode including an inner metal tube-portion extending entirely through the device; said enclosure-means including an insulating seal-means at each end of the device, between the two main electrodes; the metal tube-portion of said cathode carrying cathode-fins in good thermal and electrical contact therewith, said cathode-fins extending toward the metal tube-portion of said anode; an outer heat-exchange means disposed outside of said outer metal tube-portion; and an inner heat-exchange means extending through said inner metal tube-portion; said outer and inner heat-exchange means being at such diverse temperatures that the cathode is kept considerably hotter than the anode.

4. The invention as defined in claim 3, characterized by said inner heat-exchange means comprising means for causing a heat-exchanging fluid to move through the inner metal tube-portion, entering at one end and leaving from the other end.

5. The invention as defined in claim 3, characterized by the cathode being the electrode having the inner metal tube-portion.

6. The invention as defined in claim 3, characterized by the anode being the electrode having the inner metal tube-portion.

7. The invention as defined in claim 6, characterized by the inner heat-exchange means comprising means for causing a cooling-fluid to move through the inner metal tube-portion, entering at one end and leaving from the other end.

8. The invention as defined in claim 7, characterized by each insulating seal-means, at each end of the device, surrounding, and being spaced radially from, the corresponding end of the inner metal tube-portion, so as not to be directly contacted by said moving cooling-fluid which moves through the inner metal tube-portion.

9. A vapor-electric device comprising an evacuated enclosure-means, an anode, a cathode, and a quantity of a discharge-metal within the device, said discharge-metal being a stable alkali-metal having more than three shells in its atomic structure; said cathode including a metal tube-portion constituting side-walls of said enclosure-means, said metal tube-portion of said cathode carrying interiorly extending cathode-fins in good thermal and electrical contact therewith; said anode including a metal tube-portion extending interiorly of said enclosure means and inside of said finned portion of the cathode; said enclosure-means including an insulating seal-

6

means between said cathode and said anode; means for heating the outside of the metal tube-portion of said cathode; and means for cooling the inside of the metal tube-portion of said anode.

10. The invention as defined in claim 9, characterized by said anode tube-portion being a re-entrant tube, closed at its inner end, said cooling means comprising means for causing a cooling-fluid to enter said re-entrant tube through its open end to circulate through said re-entrant tube, and to leave it again through said open end; and said insulating seal-means being disposed between said open end of the re-entrant anode-tube and the corresponding end of the cathode tube-portion, said insulating seal-means surrounding, and being spaced radially from, said open end of the re-entrant anode-tube, so as not to be directly contacted by said moving cooling-fluid which circulates in said anode-tube.

11. A vapor-electric device comprising an evacuated enclosure-means, an anode and a cathode constituting the two main electrodes of the device, and a quantity of a discharge-metal within the device, said discharge-metal being a stable alkali-metal having more than three shells in its atomic structure; one of said main electrodes including an outer metal tube-portion constituting side-walls of said enclosure-means; the other main electrode including an inner metal tube-portion extending entirely through the device; said enclosure-means including an insulating seal-means at each end of the device, between the two main electrodes; the metal tube-portion of said cathode carrying cathode-fins in good thermal and electrical contact therewith, said cathode-fins extending toward the metal tube-portion of said anode; an outer heat-exchange means disposed outside of said outer metal tube-portion; and an inner heat-exchange means extending through said inner metal tube-portion; said outer and inner heat-exchange means being at such diverse temperatures that the cathode is kept considerably hotter than the anode.

12. The invention as defined in claim 11, characterized by said inner heat-exchange means comprising means for causing a heat-exchanging fluid to move through the inner metal tube-portion, entering at one end and leaving from the other end.

13. The invention as defined in claim 11, characterized by the cathode being the electrode having the inner metal tube-portion.

14. The invention as defined in claim 11, characterized by the anode being the electrode having the inner metal tube-portion.

15. The invention as defined in claim 14, characterized by the inner heat-exchange means comprising means for causing a cooling-fluid to move through the inner metal tube-portion, entering at one end and leaving from the other end.

16. The invention as defined in claim 15, characterized by each insulating seal-means, at each end of the device, surrounding, and being spaced radially from, the corresponding end of the inner metal tube-portion, so as not to be directly contacted by said moving cooling-fluid which moves through the inner metal tube-portion.

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No references cited.