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Jules et al.

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[54] **SERIES-CONNECTED THERMIONIC ENERGY CONVERTERS**

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[52] **U.S. Cl.** **310/4**

[51] **Int. Cl.** **H01j 45/00**

[58] **Field of Search** 310/4

[56] **References Cited**

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[57] **ABSTRACT**

A series-connected assembly of thermionic devices for the generation of electrical power having a series of cylindrically spaced apart, axially aligned, heated cathodes, a tubular cooled anode surrounding each cathode, interelectrode leads connecting each anode to its adjacent cathode, an ionization promoting vapor filling the interelectrode gaps characterized by shielding members positioned between the cathodes and the interelectrode leads and their adjacent higher potential cathodes, a tortuous path communicating between the interelectrode gaps of succeeding devices for circulating the ionization promoting vapor and an insulating member axially engaging the end of each cathode for supporting and centering the cathodes within the anodes.

16 Claims, 3 Drawing Figures

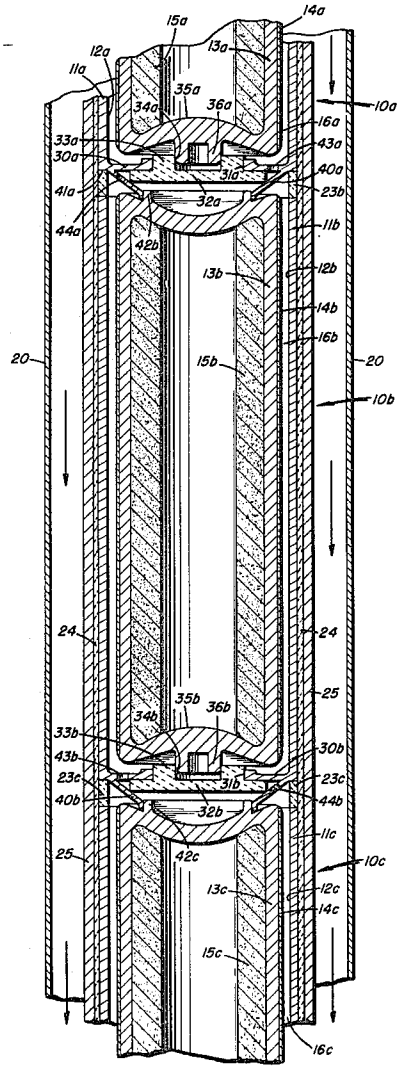


FIG. 1.

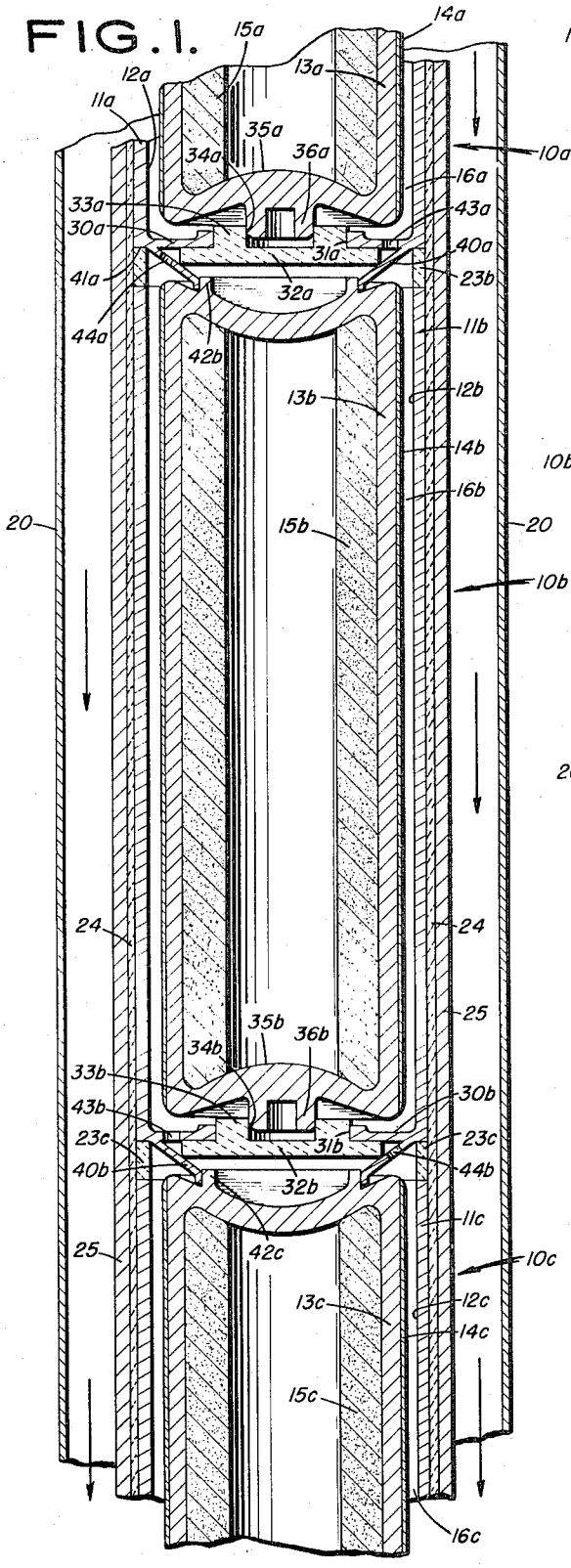
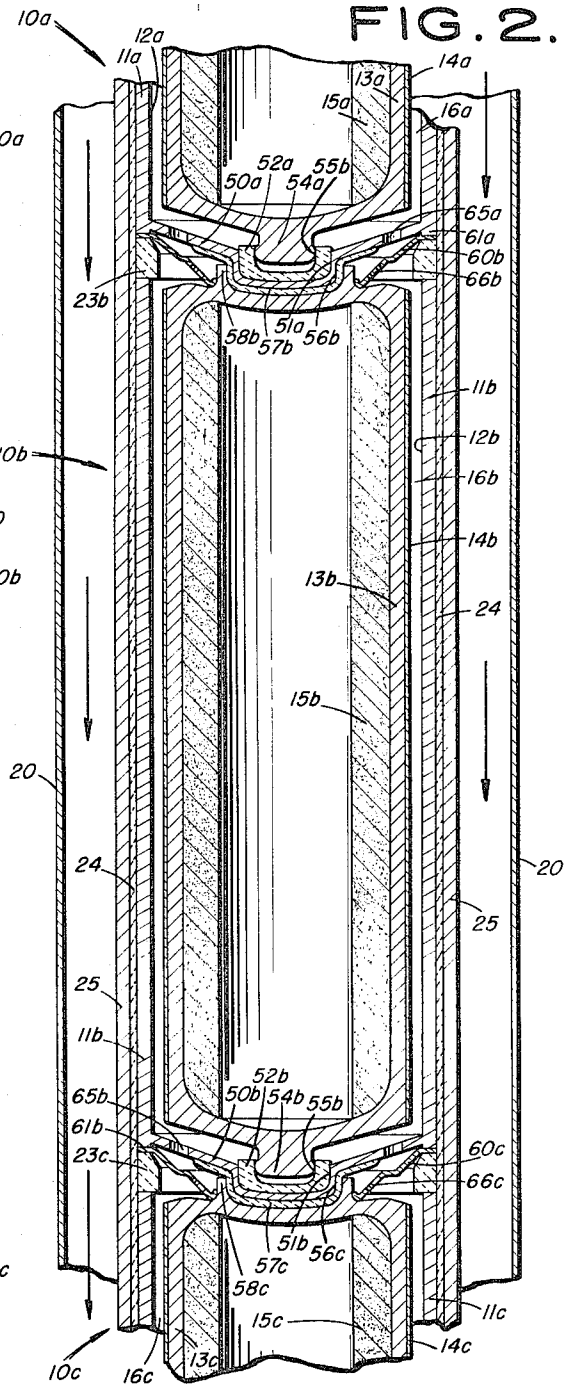


FIG. 2.



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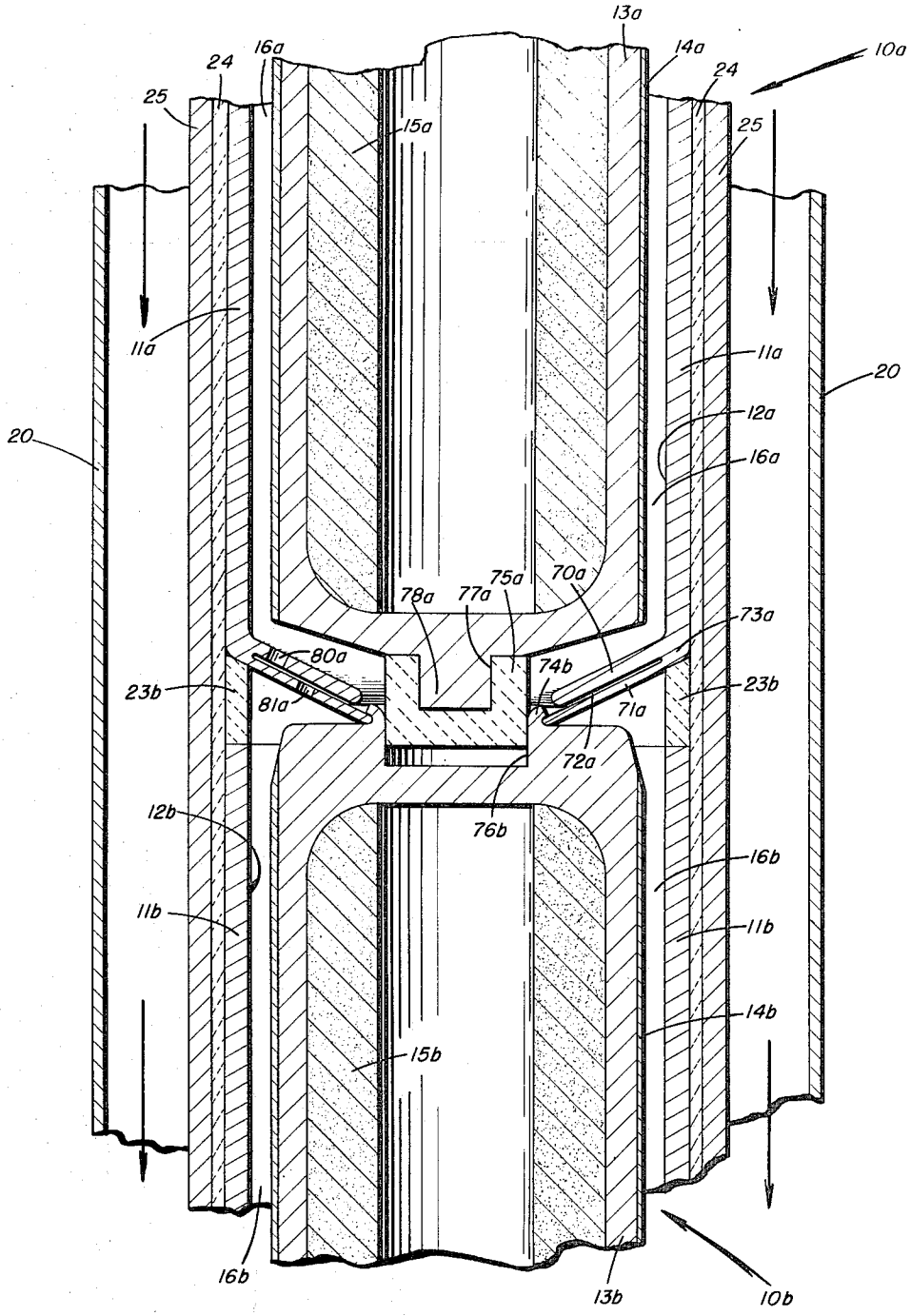


FIG. 3.

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SERIES-CONNECTED THERMIONIC ENERGY CONVERTERS

This invention relates to thermionic energy converters and more particularly to improved constructions for such devices for promoting uniformity in the output power obtainable from such devices and for facilitating the interconnection of a plurality of thermionic devices in series.

Among the important considerations which affect the electrical power output obtainable from thermionic devices such as diodes are those of interelectrode spacing in a single diode and interelectrode connections between successive series-connected diodes. The phenomena of electrical power generation by the thermionic mechanism are essentially thermodynamic. Thus, in the determination of the structure by which interelectrode separations are maintained and interelectrode connections are made, thermodynamic factors are exceedingly influential. Indeed, the thermal gradients in a thermionic power generation system are determinative of the electrical gradients. The electrical gradients on the other hand, if not properly controlled, can alter the essential thermal gradients and adversely effect the performance of the system.

The interelectrode spacing between anode and cathode in a thermionic diode is critical. If it is not uniform the power density in the diode is altered and the power output of the diode either declines or builds to destructive peaks in particular areas of the diode. For example, if one portion of the emitter surface on the cathode moves closer to the collector surface of the anode in such a device during operation, either through structural failure or through lack of precision in the construction of the device, the increased local thermal gradient across the interelectrode gap at that portion leads to a localization and concentration of current flow. As a result, one portion of the cathode and of the anode may become overloaded to the detriment of the thermodynamic properties of the device and other portions of the anode and cathode then fail to function at peak efficiency.

In the generation of higher potentials by thermionic diodes it is common to connect a plurality of diodes in series. Any two such series-connected thermionic diodes are capable of developing a significant potential difference between them. Electrons emitted from the lower potential emitter or from the interelectrode lead connected to it can arc across to the emitter of the next succeeding diode resulting in a short circuit which greatly reduces the useful power output. This problem can become far more serious when many diodes are connected in series, for it is possible to develop an arc along the entire series-connected path from one end to the other through the cathodes and thereby effectively to short-circuit the entire chain of diodes.

This invention has a principal object to maximize the electrical power obtainable from thermionic energy converters through the provision of constructions which promote uniformity of power output within and among a number of devices in a system.

An additional object of this invention is to provide new and improved thermionic diode constructions which properly balance the thermodynamic and electrodynamic principles upon which the operation of such devices are based to improve the power distribution and power density and thereby to increase the operating efficiency of such devices.

This invention has as a still further object to provide means to maximize the electrical power obtainable by thermionic diodes by preventing arc-over between the electrodes of series-connected diodes.

It is a still further object of the invention to provide thermionic diodes with improved means for maintaining the interelectrode spacing therein both constant and uniform to improve the efficiency and power output obtainable therefrom.

By way of a brief summary, the present invention may be embodied in thermionic diode constructions which act simultaneously to center a cathode within a surrounding anode and to prevent arc-over between series-connected diodes while maintaining consistant thermal gradients between the cathodes and the anodes. In one form the invention employs a metallic back-emission shield, a relatively cold member interposed between two csthodes. The back-emission shield may comprise a disc-like member connected to one anode and interposed between two cathodes at different potentials. This back-emission shield is sufficiently thick to conduct any heat which is either received by it from radiation or generated within it by small electrical currents outward to the relatively cool collector or anode with little temperature gradient. The back-emission shield is at essentially the same temperature and electrical potential as is the anode. An interelectrode lead attached to the collector at the same point as the back-emission shield and thus at the same electrical potential with it is connected to the cathode of the next succeeding thermionic diode. The interelectrode lead may have a much smaller cross-sectional area than that of the interelectrode spacer to inhibit the flow of thermal energy therethrough to the anode with which it is connected. Thus, a substantial thermal gradient develops across the interelectrode lead. An insulating member mounted at the central portion of either the back-emission shield or the interelectrode lead has a configuration which mates with that of the cathode mounted within the first anode and centers it axially therein.

Any electrons emitted by the interelectrode lead or by the cathode to which it is connected and travelling in the direction of the adjacent cathode of more positive potential are collected by the back-emission shield and are returned via an internal low resistance conducting path producing a low-loss internal electrical loop. Only electrons emitted by the back-emission shield itself can reach the adjacent more positive emitter. However, since the back-emission shield is at approximately the same temperature as the anode to which it is connected, comparatively few electrons are emitted from it and the short circuiting effect is negligible.

To provide proper out-gassing between the series-connected diodes and effective pressure control of the ionization vapor, flow passages are provided through the back-emission shield and the interelectrode lead. These passages may be located eccentrically such that the ionization vapor in passing through them follows a tortuous route. Alternatively, the passages may be located near the perimeter of the shield and lead in positions not aligned between successive cathodes. This avoids the formation direct line-of-sight emission path between successively interconnected emitters without

restricting the flow of the ionization vapor through the series-connected diodes.

Although the scope of this invention is defined in the claims appended hereto, further details of the invention as well as additional objects and advantages will be more readily understood in connection with the following description taken together with the annexed drawings in which:

FIG. 1 illustrates a longitudinal cross-sectional view of an assembly for the generation of electrical power constructed in accordance with this invention and comprising a plurality of series-connected thermionic diodes;

FIG. 2 is a view similar to that of FIG. 1 showing an alternate embodiment of the invention; and

FIG. 3 is a similar view of a still further embodiment of the invention.

Turning attention now to FIG. 1, an assembly may be seen in which a plurality of thermionic diodes **10***a*, **10***b*, **10***c*, and **10***d* are connected in series. Throughout the following description the same reference numbers are employed to identify corresponding elements in the separate diodes with letter subscripts to designate the particular diodes with which these elements are associated. Each diode includes a tubular anode **11** of circular cross-section having a collector surface **12** on the inner side thereof. Within each of the diodes is located a cylindrical cathode **13** which may have a special emitter coating **14** on the external side thereof. In the embodiment shown the cathode is heated by self-contained fissionable material bearing fuel solid **15.**

The nature of the fuel solid **15** as well as its structure and containment within the cathode **13** are not the subject of this invention. Preferably these portions of the diode are constructed as described more fully and claimed in a copending application Ser. No. 384,080 filed in the name of James Monroe on July 21, 1964.

The process by which large amounts of energy are released through nuclear fission reactions is now quite well known. In general a fissionable atom, in this case within the fuel solid **15,** absorbs a neutron and its nucleus and undergoes a nuclear disintegration. This produces fission products of lower atomic weight having great kinetic energy, and two or more neutrons also having high energy. The kinetic energy of the fission products is quickly dissipated in the fuel as heat. If, after this heat generation, there is at least one net neutron remaining which induces a subsequent fission, the fission reaction becomes self sustaining and the heat generation by the fuel solid **15** is continuous. The heat generated internally raises the surface temperature of the cathode **13** to a level above 1,500°K, at which temperature substantial numbers of electrons are emitted by the cathode **13** or its emitter coating **14.** These electrons travel across the interelectrode space **16** to the collector surface **12** of the anode **11** thereby transporting a current and producing a substantial potential difference between the cathode **13** and the anode **11.** To assist in the thermionic mechanism it is preferable for the interelectrode gap **16** to be filled with the vapor of an alkali metal, such as cesium, at a pressure of approximately 0.5 millimeters of mercury.

Despite the narrowness of the interelectrode gap, which may be on the order of 0.01 inch to 0.03 inch, for example, the anode **11** should remain at a much lower temperature than that of the cathode **13** for best results. Therefore, cooling means are provided which are represented in this case by a cooling jacket **20** surrounding the anodes **11.** A coolant is circulated through the jacket **20** to maintain the anodes at a temperature between 600°K and 1,300°K.

It is necessary that the anodes **11** be electrically isolated from each other. For this purpose annular insulators **23** are positioned between adjacent anodes **11** and may be sealed to one or both. A layer **24** of electrical insulation, preferably formed of a sleeve of Al_2O_3, also surrounds all of the anodes **11.** Insulating layer **24** is, however, preferably quite thin, on the order of 0.01 inch, to promote the rapid transfer of heat therethrough. A metal sheath **25** surrounds the insulating layer **24** and is in direct contact with the coolant in jacket **20.** The insulating layer **24** may be bonded either to the anode **11** or to the metal sheath **25** or to both.

In the practice of this invention each anode **11** is provided at one of its ends with an integral back-emission shield **30** which is formed of a high conductivity material, preferably the same material employed for the anode itself, and is shaped into a somewhat disc-like configuration. Shield **30** is of substantial cross-section so that despite its proximity to cathode **13,** it is at approximately the same temperature as anode **11** with a comparatively small internal thermal gradient.

In this embodiment the back-emission shield **30** has a central aperture **31** within which is positioned a flanged support member **32.** Support member **32** is preferably formed of a material such as sintered Al_2O_3 which is a good electrical insulator. Support member **32** includes a central neck **33** of reduced cross-sectional diameter which fits within the aperture **31** in the back-emission shield. Within neck **33** an axially centered bore **34** of still smaller diameter is provided.

It is to be noted that cathodes **13** carry on their lower domed end caps **35** a circular extension **36** which fits closely within the bore **34** of the insulating support member **32.** Either bore **34** or extension **36** or both may be tapered slightly to effect a precise axial alignment between the members thereby determining the concentricity of one end of each cathode **13** within its surrounding coaxial anode **11** and fixing the interelectrode gap **16.** Although the entire surface of each of the cathodes **13** including the end caps **35** is at a temperature elevated substantially above that of the associated anodes, the combination of a thermal insulating support member **32** within a shield **30** of high conductivity and broad cross-sectional area results in the interposition of a relatively cool member between cathodes **13***a* and **13***b* and between cathodes **13***b* and **13***c* and so on down the series.

Also in accordance with this invention an interelectrode lead **40** is provided to connect the anode **11** of each diode to the cathode **13** of the next succeeding diode. Interelectrode lead **40,** which is somewhat conical in shape, is affixed at its outer diameter to the anode **11** at the point of juncture **41** between the anode and the back-emission shield **30.** At its innermost diameter the interelectrode lead **40** terminates in contact with a circular flange **42** on the cathode **13** in the next succeeding diode, establishing an equipotentiality between the anode of one diode and the cathode of the next.

The cross-sectional current-carrying thickness of interelectrode lead **40** is, however, thinner than that of the back-emission shield **30,** and preferably is as thin as possible consistent with the magnitude of the currents which it must conduct. Thus, a substantial thermal gra-

dient develops across the interelectrode lead **40** between its hot innermost end at **42** and its cooler outermost end at **41.** In this embodiment the interelectrode lead **40** also functions as a structural centering member to locate the uppermost end of each of the cathodes as seen in this illustration and thereby to determine with precision the thickness of the interelectrode gap **16.**

In filling the interelectrode gaps of the respective diodes with vapors of cesium or other alkaline metals it is desirable to have some continuity between the several diodes so that the pressure of the ionizing vapor may be controlled in all diodes simultaneously and with the same structure. The back-emission shield **30** is therefore provided with at least one port **43** through which the cesium vapor may flow and the interelectrode lead **40** is also provided with a similar port **44.** These ports are positioned eccentrically with respect to one another to provide a tortuous path for the flow of the cesium vapor thereby to minimize the possibility of the formation of line-of-sight arcs through the cesium vapor from cathode to cathode.

Attention is directed to the alternate form of the invention shown in FIG. **2.** The form and arrangement of the components of this assembly are similar to those in the preceding embodiment and for this reason corresponding elements of the assembly are identified by the same reference numbers as are employed in connection with the first embodiment. A major difference present in this second embodiment resides in the use of the back-emission shield **50** to determine the axial orientation of the cylindrical cathodes on both sides of it. Thus, the disc-like emission shield **50** incorporates at the central portion thereof a recess **51** within which is positioned a cup-shaped support member formed of an electrically and thermally insulating material. The axial extension **54** on the cathode **13** above fits tightly and precisely within the cavity **55** formed in the insulating support member **52.** The interelectrode gap **16** and particularly its uniformity is determined in part by the precision of the centering of the cathode extension **54** within the central bore **55** in the insulating member **52.**

The configuration of the back-emission shield **50** which provides the recess **51** on one side of the shield results in a dome-like knob **56** on the opposite surface. Over this knob is fitted a plate-like layer **57** of an insulating material. This latter layer **57** fits within the flanged ring **58** projecting symmetrically from the top end of the next succeeding cathode. It can thus be seen that the back-emission shield **50** with its insulators **52** and **57** determines the interelectrode spacing of the cathode structures on both sides of it.

In this embodiment the roughly conical interelectrode lead **60** is not employed in a dual capacity to assist in the centering of the cathode. Interelectrode lead **60** is again attached to the anode **11** at its point of juncture **61** with the back-emission shield **50** and extends into electrical contact with the upper surface of the next succeeding cathode. Also because of the reduced cross-sectional current-carrying thickness of the interelectrode lead **60,** a substantial thermal gradient is developed across it although it maintains the anode **11** to which it is connected at a potential equal to that of the next succeeding cathode **13.**

A tortuous path for the flow of ionization-promoting vapors between diodes is provided by one or more channels **65** in shield **50** and one or more channels **66** in interelectrode lead **60.** This tortuous path, as in the previous example, results in a path between adjacent diodes which is not on a line-of-sight between respective cathodes.

A still further embodiment is shown in FIG. **3** wherein, once again, similar reference numbers are employed to identify elements of the combination which are substantially identical with corresponding elements in the preceding illustrations. In this embodiment the relatively cool back-emission shield **70** has only the one function of preventing short circuiting emission paths between cathodes and does not participate in the centering of the cathodes **13** within the anodes **11.**

The centering function is fulfilled in part in this embodiment by the interelectrode connector **71** which is separated from the back-emission shield **70** by a narrow space **72.** The interelectrode connector **71** extends from the lower end **73** of the anode **11** to which it is connected into engagement with the rolled-over lip **74** on the top surface of the cathode **13** in the next succeeding thermionic device. This engagement not only connects the upper anode **11***a* electrically to the next succeeding cathode **13***b*, but also centers the lower cathode **13***b* in place, determining the uniformity of the interelectrode gap **16***b*.

The upper cathode **13***a* is centered by means of an insulating support member **75** which, nested within a recess **76** in the upper end of the lower cathode **13***b*, receives within its bore **77** a centering projection **78** on the lower end of the upper cathode **13**a, thereby fixing the upper cathode **13***a* on the axis of symmetry of the assembly. A path for the circulation of ionization vapors through the series-connected diodes avoiding line-of-sight routes between successive cathodes may be provided in this instance by nonaligned apertures **80** and **81** through the back-emission shield **70** and the interelectrode connector **71** respectively.

It is to be noted that the back-emission shield **70** terminates at its innermost portion short of contact with any other member. Specifically, it does not support or contact the insulating support member **75.** This arrangement results in the back-emission shield **70** having a somewhat smaller thermal gradient and cooler average temperature than in the previous two examples of the invention.

At this point it should be apparent that there have been shown and described thermionic diode assemblies which satisfy the objectives of the invention and provide the advantages referred to above. While but three examples have been illustrated herein, it is to be understood that these examples are offered as illustrative of the invention and not necessarily to limit the scope thereof. Other variations and modifications of the invention in addition to those specifically shown and described herein will doubtless occur to those skilled in the art to which the invention pertains and the appended claims are intended to encompass all such variations and modifications as fall within the true spirit and scope of the invention in its broader aspects.

What is claimed is:

1. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical spaced apart axially aligned heated cathodes;

a series of tubular axially aligned cooled anodes each surrounding a respective one of said cathodes;

a series of interelectrode leads electrically connecting said anodes to said cathodes of adjacent said devices; and

a series of conductive back emission shields, each joined to a respective one of said anodes at one end thereof and extending into the spaces between adjacent cathodes and between said interelectrode leads and their adjacent higher potential said cathodes, said shields remaining substantially cooler than said cathodes by virtue of their conductivity and their connections to said cooled anodes.

2. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical, spaced-apart and axially aligned heated cathodes;

a series of tubular axially aligned cooled anodes each surrounding a respective one of said cathodes;

at least one insulating support member for supporting and centering said cathodes within said anodes with interelectrode gaps therebetween:

interelectrode connectors connected from the anode of each device to the cathode of the next succeeding device, said connectors developing a substantial thermal gradient thereacross by virtue of the direct connections between a heated electrode at one end and a cooled electrode at the other; and

a series of conductive metallic shields, each joined to a respective one of said anodes at one end thereof and extending into the spaces between adjacent cathodes and between said interelectrode connectors and their adjacent higher potential said cathodes, said shields remaining substantially cooler than said cathodes by virtue of their conductivity and their connections to said cooled anodes.

3. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical, spaced-apart and axially aligned heated cathodes;

a series of tubular axially aligned cooled anodes each surrounding a respective one of said cathodes;

a series of conductive metallic shields, each joined to a respective one of said anodes at one end thereof and extending into the spaces between adjacent cathodes, said shields remaining substantially cooler than said cathodes by virtue of their conductivity and their connections to said cooled anodes;

at least one insulating support member mounted on a central portion of each of said shields for supporting and centering said cathodes within said anodes with interelectrode gaps therebetween;

interelectrode connectors separate from said shields connected from the anode of each device to the cathode of the next succeeding device, said connectors developing a substantial thermal gradient thereacross by virtue of the direct connections between a heated electrode at one end and a cooled electrode at the other.

4. The combination, with a plurality of substantially identical thermionic energy conversion devices for the generation of electrical power each including a tubular cooled anode, a cylindrical heated cathode mounted within said anode, and an interelectrode gap between said anode and cathode filled with an ionization-promoting vapor in operation, comprising:

at least one support member of insulating material centering the cathodes on the axis of symmetry of said anodes and electrically insulated therefrom;

an interelectrode metallic connector connected from the cooled anode of each device to the heated cathode of the next succeeding device; and

a disc-like conductive back emission shield connected to one end of each of said anodes and inwardly extending therefrom so as to be positioned between said interelectrode metallic connectors and their adjacent higher potential said cathodes, said shield remaining substantially cooler than said cathode by virtue of its conductivity and its connection with said cooled anode.

5. In combination, a plurality of thermionic devices for the generation of electrical power, said devices being connected electrically in series and each comprising:

a tubular anode;

a cylindrical cathode concentrically positioned within said anode and separated therefrom by an interelectrode gap;

insulating support means engaging and centering said cathode within said anode;

means for heating said cathode to an elevated temperature above that of said anode;

an interelectrode connecting member joined to said anode and extending inwardly and axially into engagement with the cathode in the next succeeding thermionic device; and

an annular metallic shield connected at one end of said anode and extending inwardly therefrom between said cathode and said interelectrode connecting member.

6. A series-connected assembly of thermionic diodes for the generation of electrical power comprising:

a series of cylindrical spaced-apart and axially aligned heated athodes;

a series of tubular axially aligned cooled anodes each surrounding a respective one of said cathodes;

at least one insulating support member for supporting and centering said cathodes within said anodes with interelectrode gaps therebetween;

an ionization-promoting vapor filling each of said interelectrode gaps in operation;

interelectrode connectors electrically connecting the anode of each diode to the cathode of the next succeeding diode, said connectors developing a substantial thermal gradient thereacross by virtue of the direct connections between a heated electrode at one end and a cooled electrode at the other; and

a series of conductive metallic shields, each joined to a respective one of said anodes at one end thereof and extending into the spaces between adjacent cathodes and between said interelectrode connections and their adjacent higher potential said cathodes, said shields remaining substantially cooler than said cathodes by virtue of their conductivity and their connections to said cooled anodes, there further being an open pathway between successive interelectrode gaps for the flow of said ionization promoting vapor therethrough.

7. The combination, with a plurality of substantially identical thermionic energy conversion devices for the generation of electrical power each including a tubular cooled anode, a cylindrical heated cathode mounted within said anode, and an interelectrode gap between said anode and cathode filled with an ionization-promoting vapor in operation, of means for connecting said devices electrically in series with substantially

equipotential connections between the anode of one device and the cathode of the next succeeding device and for accurately centering the cathode within the anode of each of said devices to provide a preselected interelectrode gap therebetween, said means comprising:

at least one axially mounted support member of insulating material, each of said cathodes having at at least one end a configuration mating with that of said support member to center the cathodes on the axis of symmetry of said anodes and electrically insulated therefrom;

a disc-like conductive back emission shield of metal connected to one end of each of said anodes and inwardly extending therefrom, said shield remaining substantially cooler than said cathode by virtue of its conductivity and its connection with said cooled anode; and

an interelectrode metallic connector separate from said shield connected from the cooled anode of each energy conversion device to the heated cathode of the next succeeding device, there being a tortuous path communicating between the interelectrode gaps of succeeding devices for the circulation therethrough of the aforesaid ionization-promoting vapor.

8. In combination, a plurality of thermionic devices for the generation of electrical power, said devices being connected in series and each comprising:

a tubular anode;

a tubular cathode having an electron-emissive surface concentrically positioned within said anode and separated therefrom by an interelectrode gap;

insulating support means engaging and centering said cathode within said anode;

means for heating said cathode to an elevated temperature above that of said anode;

an ionization-promoting vapor filling said interelectrode gap in operation;

an interelectrode connecting member joined to said anode and extending inwardly and axially into engagement with the cathode in the next succeeding thermionic device;

an annular metallic shield connected at one end of said anode and extending inwardly therefrom so as to be positioned between said interelectrode connecting member and its adjacent higher potential said cathode; and

means defining pathway between the interelectrode gaps of successive devices for the circulation therethrough of said ionization-promoting vapor.

9. In combination: a plurality of axially aligned thermionic diodes for the generation of electrical power, said diodes being connected in series and each comprising:

a tubular cooled anode;

a tubular heated cathode having an electron-emissive surface concentrically positioned within said anode and separated therefrom by an interelectrode gap;

at least one insulating support member engaging and centering said cathode within said anode;

a metallic shield at one end of said anode extending inwardly therefrom and cooled by contact with said anode;

an interelectrode connecting member joined to said cooled anode extending inwardly and axially into engagement with the heated cathode in the next succeeding thermionic diode; and

means defining a torluous pathway between the interelectrode gaps in adjacent diodes for control of the composition and pressure of vapors in said interelectrode gaps.

10. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical, spaced-apart and axially aligned heated cathodes;

a series of tubular axially aligned cooled anodes each surrounding a respective one of said cathodes;

at least one insulating support member supporting and centering said cathodes within said anodes with interelectrode gaps therebetwwen;

a series of conductive metallic shields, each joined to a respective one of said anodes at one end thereof and extending into the spaces between adjacent cathodes, said shields remaining substantially cooler than said cathodes by virtue of their conductivity and their connections to said cooled anodes;

an ionization-promoting vapor filling each of said interelectrode gaps in operation; and

annular interelectrode connectors separate from said shields, each connected at its periphery to the anode of one of said devices and extending into contact with the cathode of the next succeeding device, said connectors developing a substantial thermal gradient thereacross by virtue of the direct connections between a heated electrode at one end and a cooled electrode at the other, there being an open pathway between successive interelectrode gaps following a tortuous route through each of the structures comprising an anode, a shield and an interelectrode connector for the flow of ionization-promoting vapors therethrough.

11. The combination, with a plurality of substantially identical axially aligned thermionic energy conversion diodes for the generation of electrical power each including a tubular cooled anode, and a cylindrical heated cathode mounted within said anode, with an interelectrode gap between said anode and cathode filled with an ionization-promoting vapor in operation, of means for connecting said diodes electrically in series with substantially equipotential connections between the anode of one diode and the cathode of the next succeeding diode and for accurately centering the cathode within the anode of each of said diodes to provide a predetermined interelectrode gap therebetween, said means comprising:

at least one axially mounted support member of insulating material, each of said cathodes having at at least one end a configuration mating with that of said support member to center the cathode on the axis of symmetry of said anode and electrically insulated therefrom;

a disc-like conductive back emission shield of metal connected to one end of each of said anodes and inwardly extending therefrom, said shield remaining substantially cooler than said cathode by virtue of its conductivity and its connection with said cooled anode; and

annular interelectrode metallic connectors separate from said shields, each connected at its periphery to the cooled anode of one diode and extending into contact with the heated cathode of the next succeeding diode, there being a tortuous path com-

municating between the interelectrode gaps of succeeding diodes for the circulation therethrough of the aforesaid ionization-promoting vapor.

12. In combination: a plurality of axially aligned thermionic diodes for the generation of electrical power, said diodes being connected electrically in series and each comprising:

a tubular anode;

a cylindrical cathode having an emitter surface thereon concentrically positioned within said anode and separated therefrom by an interelectrode gap;

insulating support means engaging and centering said cathode within said anode;

means for heating said cathode to an elevated temperature above that of said anode;

an ionization-promoting vapor filling said interelectrode gap in operation;

an annular metallic shield connected at one end of said anode and extending inwardly therefrom;

an interelectrode connecting member joined to said anode adjacent the region of juncture between said anode and said shield and extending inwardly and axially into engagement with the cathode in the next succeeding thermionic diode; and

means defining a tortuous path through the structure between adjacent diodes in communication with the interelectrode gaps thereof for the circulation therethrough of said ionization-promoting vapor.

13. In combination: a plurality of axially aligned thermionic diodes for the generation of electrical power, said diodes being connected electrically in series and each comprising:

a tubular anode;

a cylindrical cathode having an emitter surface thereon concentrically positioned within said anode and separated therefrom by an interelectrode gap;

means for heating said cathode to an elevated temperature above that of said anode;

an ionization-promoting vapor filling said interelectrode gap in operation;

an annular metallic shield connected at one end of said anode and extending inwardly therefrom;

insulating support means borne by said shield at a central portion thereof, said insulating support means engaging and centering said cathode within said anode;

an interelectrode connecting member joined to said anode adjacent the region of juncture between said anode and said shield and extending inwardly and axially into engagement with the cathode in the next succeeding thermionic diode; and

means defining a tortuous path through the structure between adjacent diodes in communication with the interelectrode gaps thereof for the circulation therethrough of said ionization-promoting vapor.

14. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical, spaced apart, axially aligned, heated cathodes;

a series of tubular, axially aligned, cooled anodes, each surrounding a respective one of said cathodes;

a series of interelectrode leads electrically connecting said anodes to said cathodes of adjacent said devices; and

means for preventing electrons emitted from said interelectrode leads and said cathodes from arcing to their adjacent higher potential said cathodes.

15. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical, spaced apart, axially aligned, heated cathodes;

a series of tubular, axially aligned, cooled anodes, each surrounding a respective one of said cathodes;

a series of interelectrode leads electrically connecting said anodes to said cathodes of adjacent said devices; and

means positioned between said interelectrode leads and their adjacent higher potential said cathodes for preventing electrons arcing from said interelectrode leads to said adjacent higher potential said cathodes.

16. A series-connected assembly of thermionic devices for the generation of electrical power comprising:

a series of cylindrical, spaced apart, axially aligned, heated cathodes;

a series of tubular, axially aligned, cooled anodes, each surrounding a respective one of said cathodes;

a series of interelectrode leads electrically connecting said anodes to said cathodes of adjacent said devices; and

means, including an insulating support member, axially engaging the end of each said cathode for supporting and centering said cathodes within said anodes with uninterrupted interelectrode gaps therebetween.

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