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THERMIONIC CONVERTER

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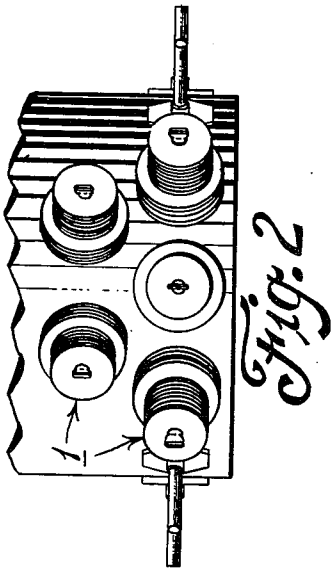


Fig. 2

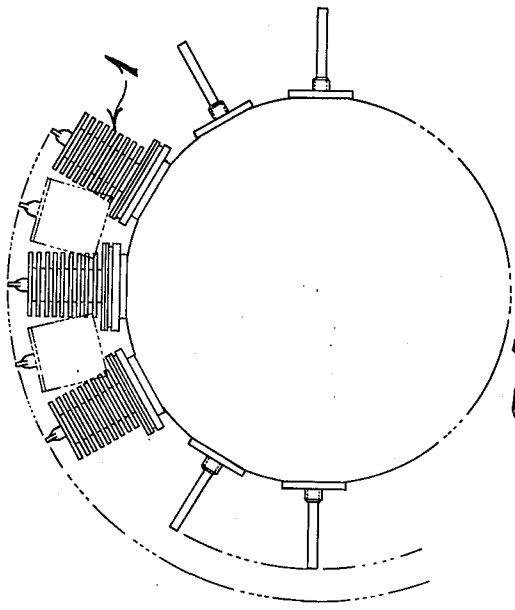


Fig. 3

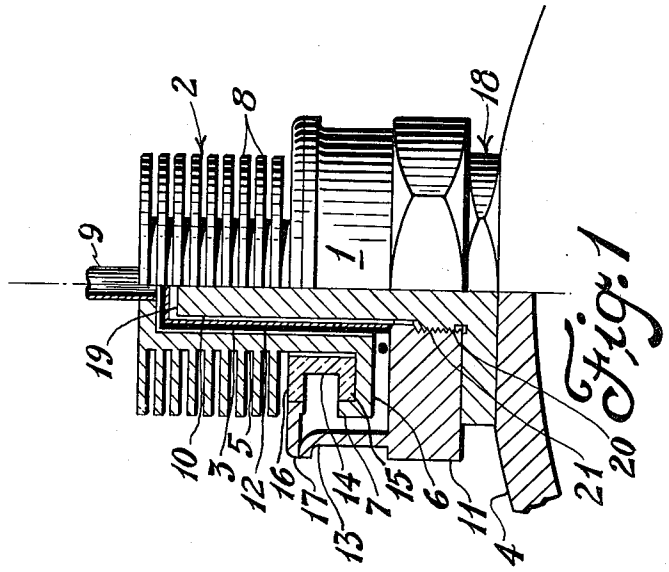


Fig. 1

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THERMIONIC CONVERTER

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The present invention relates to the direct conversion of heat to electrical power and more particularly to a thermionic converter.

A thermionic generator requires the transfer of electrons to the anode. A real barrier is present in the space charge which normally exists between the two elements. By applying heat to the cathode, some electrons are raised on a potential energy scale from the Fermi level of the cathode to the top of the potential barrier at the cathode surface. If the space charge barrier can be overcome, the electrons will flow to the anode and fall on a potential energy scale by an amount equal to the work function of the anode. This energy appears as heat in the anode. The remaining potential energy of the electrons, after they have reached the Fermi level of the anode, is the contact difference of potential which may be delivered directly as electrical energy to an external circuit connected between the anode and cathode. Thus it is apparent that if the device is to be successful, the effects of the space charge must be substantially reduced or removed.

One method investigated is the reduction of cathode to anode distance. It has been found that to obtain reasonable conversion efficiencies, spacings in the order of .00025 inch are necessary. Such spacing is not practical for manufacture, especially when large areas are necessary for a device of reasonable output.

Another method under investigation is high particle velocity. A high velotage is applied to the accelerating electrode and the electrons forced to move to the anode by a perpendicular magnetic field. For high emission current densities, impracticably high voltages and strong magnetic fields would be required.

A further method is resonance ionization in which a gas whose ionization potential is lower than the work function of the cathode is introduced into the tube. Neutral atoms striking the hot cathode will be ionized and injected as positive ions into the interelectrode space and form a plasma beam which extends from the anode to the cathode. This method overcomes the difficulties of minute spacing and does not require high voltages or magnets. Spacings in a positive ion device are greater than in the close spaced device by an order of magnitude of one hundred, thus making production feasible. One of the major problems with this method is to maintain a suitable temperature gradient between the anode and cathode. With a cathode temperature of approximately 1500 degrees C., it is desirable to hold the anode temperature to approximately 400 dgerees C. Also it is necessary to maintain a sufficient temperature gradient so that insulating seals will not exceed 600 degrees C. as a maximum.

The present invention provides a novel device in which a mixture of uranium carbide and zirconium carbide is used for the cathode material and cesium vapor for the gas filling. Further, the geometry of the device is such that a temperature gradient is established so that the temperature of the insulating seal will be below the maximum permitted by the character of the material.

It is the object of the invention to provide a novel thermionic converter.

Another object of the invention is to provide novel means for converting heat directly to electrical energy.

Another object of the invention is to provide an improved structure for a thermionic converter.

Another object of the invention is to provide improved sealing means for a thermionic converter.

Another object of the invention is to provide an improved thermionic converter which is simple to fabricate.

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawing wherein one embodiment is illustrated by way of example.

In the drawing:

FIGURE 1 is a partial cutaway view of a device embodying the invention.

FIGURE 2 is an end view illustrating the installation of devices embodying the invention.

FIGURE 3 is a side view of the devices of FIGURE 2.

Referring now to the drawing, wherein the same reference numerals are assigned to similar parts in the various figures, a thermionic converter is indicated generally by the numeral 1 and has an anode 2 and cathode 3. The converter 1 is adapted for mounting on a heat source 4 which, for example, may be the exhaust of a jet engine.

The anode 2 has a cylindrical portion 5 terminating in a radially extending fiange 6 which terminates in an axially extending flange 7. A plurality of heat radiating fins 8 surround the cylindrical portion 5 of the anode 2. The fins 8 may be integral with the anode 2 or they may be separate parts in so long as they are in good heat exchange relationship therewith. An exhaust tubulation 9 is provided in the anode 2. The anode 2 may be of a material having good oxidation resistance and good thermal conductivity such, for example, as a stainless steel.

The cathode 3 has a cylindrical section 10 adapted to be positioned into the cylindrical section 5 of the anode 2 and concentric therewith. The section 10 is secured to a base 11 which has a large mass relative to the section 10. The sections 10 and 11 may be of a suitable material having good resistance against oxidation at high temperatures and also having good thermal conductivity, for example, stainless steel. The section 10 has an emission coating 12 on the surface thereof adjacent to the anode. The coating 12 is a mixture of uranium carbide and zirconium carbide which may be prepared as set forth in co-pending application Serial No. 863,170, filed December 31, 1959, now abandoned.

The spacing between the anode 2 and cathode 3 may be in the order of .015 to .020 inch.

The cathode base 11 has an axially extending flange 13 having a circumference somewhat larger than the flange 6 of the anode 2. The flange 13 has a relatively thin wall section relative to the base 11 and extends beyond the flange 7 of the anode 2.

A ceramic ring 14 has an outwardly extending flange 15 adapted to be sealed to the flange 7 of the anode 2. The ring 14 has another outwardly extending flange 16 adapted to be sealed to a flat ring-like member 17 which is welded to the flange 13 to form a unitary structure. The flange 13 and ring member 17 serve as cooling fins for the cathode 3 in order that the temperature of the seal between the member 17 and flange 16 may be held to a safe maximum temperature.

A heat sink 18 is secured to the source of heat 4 and has an elongated portion 19 adapted to fit inside of the cylindrical section 10 of the cathode 3. The heat sink 18 may be of a material having good thermal conductivity and the ability to withstand oxidation at high temperatures, for example, stainless steel. The spacing between the cylindrical section 10 and the elongated portion 19 should be held to a minimum in order to provide good heat transfer therebetween. The heat sink 18 has a threaded portion 20 adapted to mate with an internal threaded portion 21 in the cathode base 11.

In processing, after the seal has been made, between the ceramic insulator 14, anode 2 and cathode 3, the device 1 is evacuated through the tubulation 9, provided with a filling of cesium vapor and then tipped off and sealed.

FIGURES 2 and 3 illustrate how a plurality of the devices may be installed on a heat source, such as the exhaust of a jet engine. It is understood that the devices may be connected together electrically in a conventional manner.

In a specific example, the cathode temperature was approximately 1500° C. and the anode temperature was held at approximately 400° C. With the structure disclosed, there was sufficient temperature gradient between the anode and cathode that the ceramic insulator seals were below the 600° C. maximum temperature.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangement of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention.

What is claimed is:

1. A thermal converter comprising an anode, a cathode having an emissive coating of a mixture of uranium carbide and zirconium carbide, a filling of cesium vapor between said anode and said cathode means including a fin-like member on said cathode for forming a vacuum type seal between said anode and said cathode and cooling means for said anode whereby a temperature differential is maintained between said anode and cathode.

2. A thermal converter comprising a cathode having a cylindrical section and a base section having a large mass relative to said cylindrical section, an emissive coating of a mixture of uranium carbide and zirconium carbide on the outer surface of said cylindrical section, a cylindrical anode surrounding said cylindrical section of said cathode and concentric therewith, a plurality of cooling fins in heat exchange relationship with said anode, means including a dual flanged ceramic member for forming a vacuum tight seal between said anode and said cathode whereby sufficient temperature gradient is maintained so that said seal is maintained below a predetermined temperature, a gas filling for said converter, and a heat sink adapted for placement inside of said cylindrical section of said cathode to supply heat thereto.

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