June 22, 1965 H. HUBER ETAL 3,191,076

ENERGY CONVERTER

Filed May 5, 1961 2 Sheets-Sheet 1

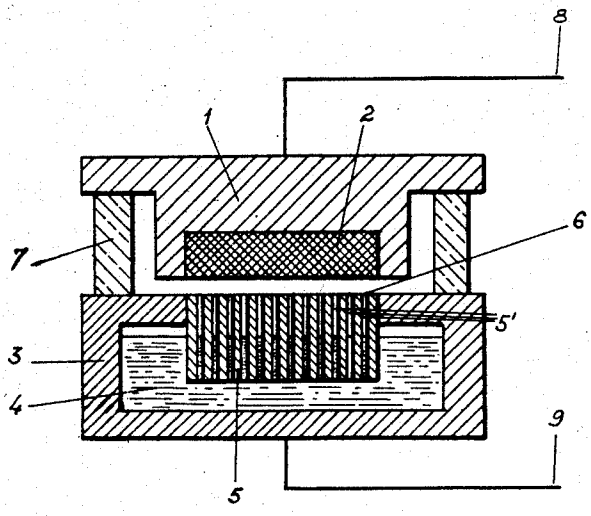


FIG. 1

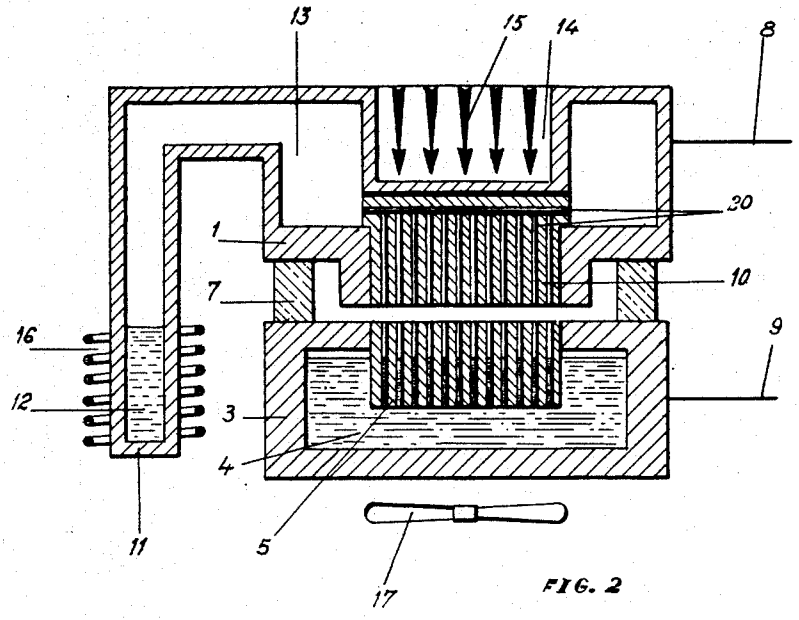


FIG. 2

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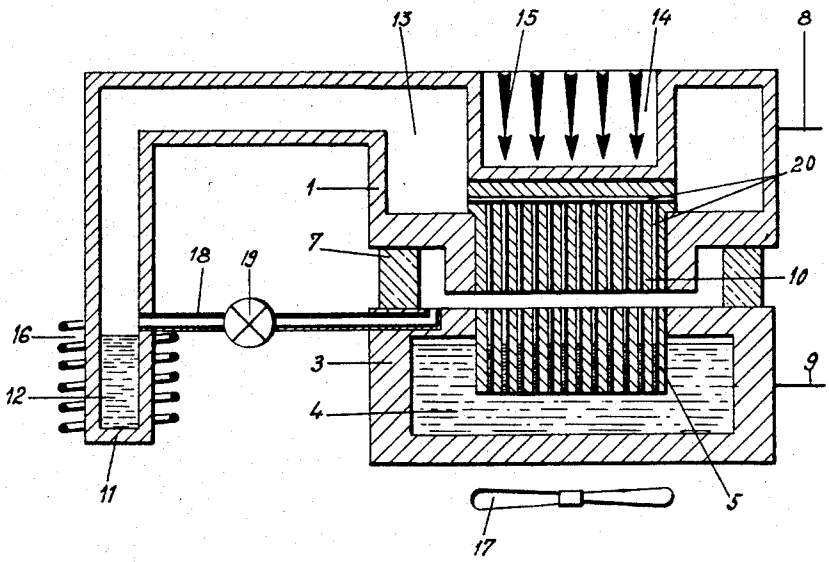


FIG. 3

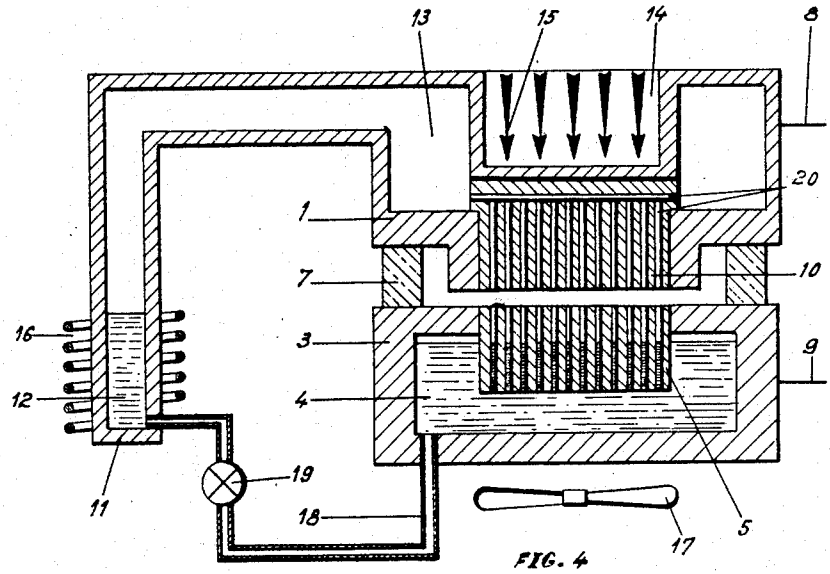


FIG. 4

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United States Patent Office 3,191,076 Patented June 22, 1965

3,191,076

ENERGY CONVERTER

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Filed May 5, 1961, Ser. No. 108,062
Claims priority, application France, May 17, 1960, 827,393
21 Claims. (Cl. 310—4)

The present invention relates to direct thermo-electronic converters for converting directly thermal energy into electrical energy.

It is known that in its simplest form, such a converter comprises a pair of electrodes, particularly an emitter and an electron collector, disposed within a vacuum-tight enclosure at a mutual distance preferably no greater than the average free path of the electrons within the medium filling the enclosure. These electrodes may be insulated from one another or also may be connected by a relatively resistant metallic conductor, but at any rate no voltage from an external source is applied therebetween. When heat is applied to the emitter, the energy of certain electrons within the emissive material increases beyond the working potential, whereupon these electrons leave the emitter and move in the direction toward the collector provided the interelectrode space charge effects are not too significant. If the working potential of the material of the collector is less than that of the emitter, the portion of the energy of the electrons captured by the collector, corresponding to the working potential thereof, is dissipated in the form of heat, whereas the remaining portion, corresponding to the difference in working potentials between two electrodes, represents the difference in contact potential and appears between the emitter and the collector in the form of an electric voltage which may be applied to a suitably matched charging resistance.

As already indicated hereinabove, the possibility for operation of such a device depends on the absence or negligible importance of the effects of the space charge. It is, therefore, necessary to compensate for the latter, and it is already known in the prior art to do so by introducing within the enclosure an ionizable gas or vapor, for example, of cesium, potassium or rubidium of which the ionization potential is less than the working potential of the material of the surface of a conductor on which fall the atoms of the gas or of the vapor filling the enclosure which condense thereon. This surface may be that of the emitter or that of a separate auxiliary electrode in which case the converter is no longer a diode but becomes a triode. It is also possible to utilize a non-homogeneous emitter comprising alternate emissive portions with non-emissive portions forming the surface in question.

If this surface is sufficiently hot so that the atoms may re-evaporate, many among them lose an electron and escape from the surface in the form of positive ions. As a result of this phenomenon, known usually under the name of surface or contact ionization, ions are obtained which intermingle or mix with the electrons of the space charge and neutralize the charge thereof by forming a plasma. The converters utilizing this manner of compensating the space charge are usually called "plasma" converters or "wet" converters, and the present invention relates more particularly to this type of converter.

As has been indicated, the useful voltage of a converter corresponds to the difference in working potentials of the emitter and collector so that there exists an interest, in order to increase this voltage, to utilize as emitter a material having as high as possible a working potential, and as collector a material having as low as possible a working potential. Insofar as the emitter is concerned, one

approaches rapidly the limitation by reason of the fact that the materials having a high working potential necessitate relatively high temperatures to emit electrons, and practical considerations may preclude exceeding a certain reasonable temperature. There remains, therefore, the second way, namely that of choice for the collector of a material having a low working potential, however, the first obstacle which is encountered in this approach is the work function or work potential of ionizable materials normally utilized, that is of cesium, potassium, or rubidium, which extend between 1.9 ev. for cesium and 2.2 ev. for potassium.

In effect, the materials which have working potentials lower than the values corresponding to these figures are unstable in operation and cannot be introduced into the converter by starting with the prefabricated state thereof, and even if the manufacture of such stable materials were realized, the working potential of a collector made of these materials would increase progressively up to the level of the working potential of the ionizable material by reason of the fact of unavoidable deposits of this material on the collector in the course of operation of the converter.

The object of the present invention is a "wet" converter for converting thermal energy into electrical energy in which the collector is realized in such a manner that the working potential thereof in the dynamic state is lower than that of the ionizable material, measures being taken that the aforementioned increase in working potential to the level of that of the ionizable material cannot take place.

Accordingly, it is an object of the present invention to provide a converter adapted to convert directly thermal energy into electrical energy which effectively eliminates the disadvantages and shortcomings of similar devices known to the prior art.

It is another object of the present invention to provide an energy converter adapted to convert thermal energy into electrical energy which effectively eliminates the space charge effects occurring in such devices without producing any detrimental side-effects.

Still another object of the present invention resides in the provision of an energy converter of the type mentioned hereinabove, which permits an effective increase in the difference of working potentials between the emitter and collector.

Another object of the present invention resides in the provision of a collector electrode for direct thermo-electronic converters of which the working collector-electrode potential, in the dynamic state, is relatively low, and more particularly of which the working potential is lower than the ionizable material used to compensate for the space charge effects.

Still a further object of the present invention resides in the provision of a collector electrode for energy converters of the type mentioned hereinabove which offers the desired characteristics described hereinabove yet is effectively stable during operation.

A still further object of the present invention resides in the provision of a collector electrode for an energy converter in which the operative surface portion of a collector is constantly renewed by interaction between several substances.

Still a further object of the present invention resides in the provision of a collector electrode for energy converters of the type mentioned hereinabove which is so constructed and arranged as to effectively prevent and/or remove any excess of ionizable material from the surface of the collector electrode to prevent a progressive increase in the working potential thereof.

Another object of the present invention resides in the

provision of an energy converter in which the ionizable material used in the energy converter may constitute itself the emitter material adapted to emit the electrons.

A still further object of the present invention is the provision of emitter and collector electrode structures for energy converters as capillary bodies to improve the operation and output of the device.

Still another object of the present invention resides in the provision of means within energy converters of the type mentioned hereinabove which are effective to establish an equilibrium between the ions and space charge present therein.

A still further object of the present invention lies in the provision of an ionizable material constituting simultaneously emitter means for electrons, emitter means of ions, and reactant means for the production of a surface portion of the collector having a low working potential.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein

FIGURE 1 is a longitudinal cross sectional view of a first embodiment of an energy converter in accordance with the present invention, and

FIGURES 2–4 are longitudinal cross sectional views of three modified embodiments of an energy converter in accordance with the present invention.

It is known that the working potentials lower than those of Cs, Rb or K characterize certain combinations of the ionizable materials with certain metals or metallic oxides. Similarly, the oxides of these materials either alone or in combination with other oxides have also lower working potentials than the ionizable materials themselves. For example, when the ionizable material is cesium, the oxide of cesium itself, or combined with another oxide such as silver oxide or tungsten oxide, or combinations of Cs with metals such as Sb, K, Na, Bi, Li, alkaline earth metals, have a work function or work potential of the order of 1 ev., that is all of these composite substances are utilizable within the object of the present invention. Unfortunately, these substances are unstable or difficult to realize in a homogeneous manner.

According of the present invention, the collector of a converter converting heat into electrical energy is a capillary body, constituted at least at the surface thereof by a substance capable to form, by reaction with the ionizable material during operation of the converter, one of the aforementioned substances with a low working potential, this body being impregnated with the said ionizable material.

In this manner, the conditions for the realization of the objects of the present invention are satisfied: In effect, the collector surface is constantly renewed by the formation of the substance with a low working potential which is, therefore, maintained in the dynamic state notwithstanding the instability of the compound whereas the excess of the ionizable material flows back through the capillary channels and does not remain at the surface of the collector.

The impregnation may be readily realized by causing the bottom of the capillary body to be immersed or soaked in a liquid reservoir or tank of ionizable material.

Having thus overcome the obstacle formed by the working potential of the ionizable material and having thus realized a collector having a lower working potential than the latter, it becomes possible to utilize the ionizable material itself as electron source within the emitter of the converter which avoids effectively the perturbation of the operation by the deposits on the collector of an emissive substance other than the ionizable material, in the case in which the emitter would be constructed of such a substance.

According to another feature of the present invention, a converter provided with a collector as defined hereinabove is, therefore, provided with an emitter, known per se, made of cesium, rubidium or potassium as the case may be. In accordance with this concept, the ionizable material plays a simultaneous triple role, namely that of electron emitter by heating, that of ion emitter by impact with a surface having a working potential greater than the ionization potential, and that of reactant participating in the formation of the collector surface with a low working potential.

According to a preferred embodiment of the present invention, the emitter is constituted, in a manner analogous to that of the collector, by a capillary body supplied across the channels thereof with metallic vapor emitting electrons and ions, the mass of this body being made of a substance having a working potential higher than the potential of ionization of the emitter metal. The metallic vapor may be supplied by the surface of a liquid metal contained in a second reservoir or tank, and the temperature of this metal may be maintained and possible also be regulated by suitable means to an appropriate value in order to establish a vapor pressure corresponding to a desired flow of ionizable metal across the capillary body in such a manner as to establish an equilibrium between the ions produced and the space charge.

According to still another feature of the present invention, the excess vapor supplied through the emitter into the enclosure of the converter is recuperated and refluxed, through a circuit including pumping means, into the reservoir or tank of the emitter.

According to still a further development of the present invention, the capillary collector and its reservoir or tank are interposed into the reflux circuit in such a manner that the circulation of the ionizable material takes place in a closed circuit containing the two reservoirs or tanks.

The reservoir of the collector may also, in case of need, be maintained, by suitable means, at a temperature sufficiently low to assure a good conversion output and a good condensation of metallic vapor flowing back through the channels of the collector.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate corresponding parts, and more particularly to FIGURE 1, reference numeral 1 designates therein a metallic support for the emitter in which is embedded an emissive mass or substance 2 which may have a relatively high working potential and may operate at high temperature, for example, made of tungsten. Reference numeral 3 designates, in this figure, a tank of suitable metallic material which contains, for example, liquid cesium 4, in which is immersed a capillary body 5 according to the present invention, this capillary body 5 being supported by the walls of the tank 3. The capillary body 5 is made, for example, of sintered tungsten of which the mass is porous, and is, for example, oxidized on the surface 6 thereof facing the emitter 2 and spaced therefrom by a slight distance, for example, of the order of a fraction of a millimeter. Of course, other materials may also be used in accordance with the general explanation given hereinabove: the capillary body 5 may be made of any porous or spongy substance, for example, of sintered molybdenum or nickel, and the oxidation on the surface thereof may be replaced by the disposition on this surface of a layer of silver oxide, of alkaline-earth oxide, or of a mixture, for example, of Sb, K and/or Na. The vacuum-tight enclosure is defined or limited by a spacer 7 disposed between the supports 1 and 3. This spacer 7 may be made of insulating material but may also be made, as is known per se, of a resistant alloy such as Nichrome or Kanthal. In all cases, the liquid cesium 4 rises by capillary action through the substantially straight channels 5' within the body 5 and evaporates within the vacuum-tight enclosure in which a vacuum has been established previously. This vapor acts, on the one hand, as ion emitter according to known techniques by impact on

the hot surface of the emitter 2 and, on the other, combines with the material of the surface 6 to form a substance having very low work function. The converter is placed into operation by heating the support 1 of the emitter 2 by means of a suitable heat source, preferably by means of one of those which are ordinarily lost such as sun rays, combustion heat or residual gases of engines, losses in nuclear reactors, etc., and the utilizable voltage is collected between the conductors 8 and 9 secured, respectively, to the emitter and collector.

In the embodiment of FIGURE 2, in which again similar reference numerals are used as in FIGURE 1 to designate corresponding parts, not only the collector 5 but also the emitter comprises a capillary body 10 secured within the support 1 thereof. This body 10 is made of porous material of which the working potential is greater than the ionization potential of the ionizable material utilized, of the type of cesium 4. Consequently, this body may be preferably of sintered tungsten, but it is also possible to utilize a block of sintered molybdenum, tantalum, nickel or analogous material. The emissive material properly speaking is cesium, if cesium is used as impregnation metal for the collector 4. This cesium is derived from a tank 11 containing a reserve or supply of cesium 12 which evaporates within the vacuum-tight enclosure 13 surrounding the capillary body 10, this vacuum-tight enclosure being in communication with the evacuated enclosure of the converter through a network of capillary channels of this body, consisting of substantially straight channels and schematically indicated in this figure by reference numeral 20. An aperture or trough 14 is provided within the walls of the enclosure 13 to apply thereat a flow of heat, schematically indicated in FIGURE 2 by arrows 15, the bottom of this trough 14 being in contact with the upper side of the capillary body 10. The cesium vapor, heated to the emission temperature, descends through the capillary channels 20 of the body 10 and penetrates into the space of the converter by emitting the electrons. At the same time, the atoms of cesium fall on the non-emissive portions of the body 10 and are transformed into ions by the phenomenon of surface ionization.

Appropriate adjustable heating means, illustrated in this figure only schematically and designated therein by reference numeral 16 may be provided about the tank 11 to maintain the temperature of the cesium 12 at a suitable intermediate value between the temperatures of the emitter 10 and of the collector 5 in order to control the flow of ionizable metal through the capillary body by acting on the saturating vapor pressure.

On the other hand, suitable cooling means, again only schematically indicated in FIGURE 2 and designated therein by reference numeral 17, may be provided along the collector or its tank in order to maintain the temperature thereof at a desired temperature, for example, of the order of 100° C.

The advantage of the converters comprising an emitter of cesium or analogous material is the fact that they may operate with an emission temperature that is relatively low, of the order of 900 to 1000° C. These temperatures are acceptable in practical operation whereas the conversion output of the converter is maintained at a reasonable value owing to the maintenance of the collector at a relatively low temperature, of the order of magnitude indicated hereinabove.

FIGURE 3 differs from FIGURE 2 only by the fact that a flow and a recuperation are provided for the cesium vapor filling the interelectrode space of the converter by means of a conduit 18 provided with suitable pumping means 19, connecting the inside of the converter across the body 3 with the inside of the tank 11. Appropriate electrical insulating means are thereby interposed along these conduits to separate electrically the potentials of elements 3 and 11.

In the embodiment of FIGURE 4, the conduit 18 and pumping means 19 have been disposed between the tank 3 and the tank 11 to assure the circulation of cesium in a closed circuit, by evacuating the excesses from the tank 3 which is filled little by little owing to the condensation of the cesium vapor flowing through the capillary body 5.

While we have shown and described several embodiments in accordance with the present invention, it is obvious that the same is not limited thereto but is susceptible of many changes and modifications within the spirit and scope thereof as known to a person skilled in the art, and we therefore do not wish to be limited to the details shown and described herein only for illustrative purposes, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

We claim:

1. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said capillary means with said ionizable metal, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

2. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said capillary means with said ionizable metal including tank means containing said ionizable metal in the liquid state at the operating temperature of said collector electrode means, said capillary means being arranged to soak in said liquid metal, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

3. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means essentially made of sintered refractory metal having its collecting surface oxidized so as to effectively form, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said capillary means with said ionizable metal, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

4. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon applica-

tion of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means essentially made of sintered refractory metal having the collecting surface thereof coated with a substance capable of reacting with an ionizable metal chosen from the group consisting of cesium, rubidium and potassium to form, at the operating temperature of said collector electrode means, a compound having a working potential of the order of 1 electron-volt, and means for immersing said capillary means within said ionizable metal.

5. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means essentially made of sintered refractory metal having the collecting surface thereof coated with a substance selected from the group consisting of silver oxide, an alkaline earth oxide and a mixture of antimonium, potassium and sodium capable of reacting with an ionizable metal chosen from the group consisting of cesium, rubidium and potassium to form, at the operating temperature of said collector electrode means, a compound having a working potential of the order of 1 electron-volt, and means for immersing said capillary means within said ionizable metal.

6. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means essentially made of a sintered mass of metal selected from the group consisting of tungsten, molybdenum and nickel and operative to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form, at the operating temperature of said collector electrode means, at least at the collecting surface thereof a material having a working potential lower than the working potential of said ionizable metal, and said capillary means being in operative communication with a supply of said ionizable metal.

7. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means essentially made of a sintered mass of metal selected from the group consisting of tungsten, molybdenum and nickel and provided at the electron collecting surface with a substance selected from the group of silver oxide, alkaline-earth oxide and a mixture of potassium, antimonium and sodium operative to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form, at the operating temperature of said collector electrode means, at least at the collecting surface thereof a material having a working potential lower than the working potential of said ionizable metal and said capillary means being in operative communication with a supply of said ionizable metal.

8. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means including capillary means essentially made of a sintered mass of refractory metal powder selected from the group consisting of tungsten, molybdenum, tantalum and nickel for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means essentially made of a sintered mass of metal selected from the group consisting of tungsten, molybdenum and nickel and provided at the electron collecting surface with a substance selected from the group of silver oxide, alkaline-earth oxide and a mixture of potassium, antimonium and sodium operative to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form, at the operating temperature of said collector electrode means, at least at the collecting surface thereof a material having a working potential lower than the working potential of said ionizable metal, means for supplying an electron emissive substance through said first-mentioned capillary means with at least a substantial portion thereof essentially consisting of said ionizable metal, and said second-mentioned capillary means being in operative communication with a supply of said ionizable metal.

9. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, and means for effectively impregnating said capillary means within said ionizable metal.

10. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, and means for effectively impregnating said capillary means within said ionizable metal, said emitter electrode means including an emissive substance of the same metal as used for impregnating said collector electrode means.

11. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means including capillary means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, and means for effectively impregnating said second-mentioned capillary means with said ionizable metal, said emitter electrode means including an emissive substance of the same metal as used for impregnating said collector electrode means, and means for supplying said emissive substance through said first-mentioned capillary means into said enclosure means, at least said first-mentioned capillary means having a working potential higher than the ionization potential of said emissive substance.

12. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means including capillary means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, and means for effectively impregnating said second-mentioned capil-

lary means within said ionizable metal, said emitter electrode means including an emissive substance of the same metal as used for impregnating said collector electrode means, and means for supplying said emissive substance through said first-mentioned capillary means into said enclosure means, at least said first-mentioned capillary means having a working potential higher than the ionization potential of said emissive substance and being made of a sintered mass of refractory metal powder.

13. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said capillary means with said ionizable metal including tank means containing said ionizable metal in the liquid state at the operating temperature of said collector electrode means, said capillary means being arranged to soak in said liquid metal, means for controllingly adjusting the temperature of said tank means, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

14. An energy converter provided with a vacuum-tight enclosure means, comprising emitter electrode means including capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, feeding means for feeding said emissive substance through said first-mentioned capillary means into said enclosure means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said second-mentioned capillary means with said ionizable metal, including reservoir means containing said ionizable metal into which extends said second capillary means, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

15. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means including capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, feeding means for feeding said emissive substance through said first-mentioned capillary means into said enclosure means, said feeding means including tank means to store therein said emissive substance which is in the liquid state at the operating temperature of said tank means and connecting means operatively connecting said tank means with said first-mentioned capillary means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said second-mentioned capillary means with said ionizable metal including reservoir means containing said ionizable metal into which extends said second capillary means, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

16. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means including capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, feeding means for feeding said emissive substance through said first-mentioned capillary means into said enclosure means, said feeding means including tank means to store therein said emissive substance which is in the liquid state at the operating temperature of said tank means and connecting means operatively connecting said tank means with said first-mentioned capillary means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said second-mentioned capillary means with said ionizable metal including reservoir means containing said ionizable metal into which extends said second capillary means, temperature control means including heating and cooling means for adjustably controlling the operating temperature of said tank means and of said reservoir means, respectively, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means.

17. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means including capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, feeding means for feeding said emissive substance through said first-mentioned capillary means into said enclosure means, said feeding means including tank means to store therein said emissive substance which is in the liquid state at the operating temperature of said tank means and connecting means operatively connecting said tank means with said first-mentioned capillary means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said second-mentioned capillary means with said ionizable metal including reservoir means containing said ionizable metal into which extends said second capillary means, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means, said first capillary means being made of a sintered mass of refractory metal powder selected from the group consisting of tungsten, molybdenum, tantalum and nickel and said second capillary means being made of a sintered mass of metal selected from the group consisting of tungsten, molybdenum and nickel.

18. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means including capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, feeding

means for feeding said emissive substance through said first-mentioned capillary means into said enclosure means, said feeding means including tank means to store therein said emissive substance which is in the liquid state at the operating temperature of said tank means and connecting means operatively connecting said tank means with said first-mentioned capillary means, collector electrode means adapted to collect said electrons and including capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said metal, means for effectively impregnating said second-mentioned capillary means with said ionizable metal including reservoir means containing said ionizable metal into which extends said second capillary means, and output means operatively connected respectively to said emitter and collector electrode means to enable abstraction of electrical energy appearing thereacross upon application of heat to said emitter electrode means, said first capillary means being made of a sintered mass of refractory metal powder selected from the group consisting of tungsten, molybdenum, tantalum and nickel and said second capillary means being made of a sintered mass of metal selected from the group consisting of tungsten, molybdenum and nickel, and the collecting surface of said second capillary means being coated with a substance selected from the group consisting of silver oxide, alkaline earth oxide and a mixture of Sb, K and Na.

19. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means, first capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, means for feeding said emissive substance through said first-mentioned capillary means including first tank means containing said emissive substance, collector electrode means adapted to collect said electrons and including second capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said ionizable metal, means for effectively impregnating said second capillary means with said ionizable metal including second tank means in which soaks said second capillary means, said emissive substance being essentially the same as said ionizable metal.

20. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means, first capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, means for feeding said emissive substance through said first-mentioned capillary means including first tank means containing said emissive subtance, collector electrode mean adapted to collect said electrons and including second capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said ionizable metal, means for effectively impregnating said second capillary means with said ionizable metal including second tank means in which soaks said second capillary means, said emissive substance being essentially the same as said ionizable metal and means operatively connecting said first tank means with said second tank means for circulating said emissive substance.

21. An energy converter provided with vacuum-tight enclosure means, comprising emitter electrode means, first capillary means and an emissive substance for emitting electrons into said enclosure means upon application of heat to said emitter electrode means, means for feeding said emissive substance through said first-mentioned capillary means including first tank means containing said emissive substance, collector electrode means adapted to collect said electrons and including second capillary means having, at least at the collecting surface thereof, a material capable to react with an ionizable metal selected from the group consisting of cesium, rubidium and potassium to form at the operating temperature of said collector electrode means a material having a working potential lower than the working potential of said ionizable metal, means for effectively impregnating said second capillary means with said ionizable metal including second tank means in which soaks said second capillary means, said emissive substance being essentially the same as said ionizable metal and means operatively connecting the space intermediate said electrode means within said enclosure means and said first tank means.

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