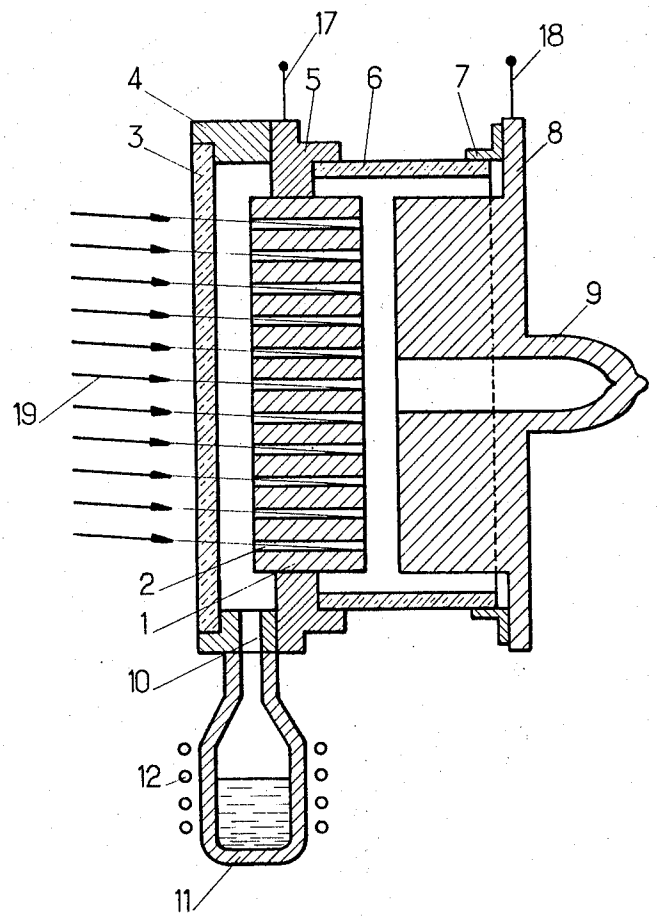
Jan. 24, 1967 J. BENSIMON 3,300,660

THERMIONIC ENERGY CONVERTER WITH PHOTON IONIZATION

Filed June 23, 1964



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United States Patent Office 3,300,660 Patented Jan. 24, 1967

3,300,660

THERMIONIC ENERGY CONVERTER WITH PHOTON IONIZATION

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Filed June 23, 1964, Ser. No. 377,238
Claims priority, application France, July 10, 1963, 941,000
4 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 work function, 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 work function 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 work function thereof, is dissipated in the form of heat, whereas the remaining portion, corresponding to the difference in work functions 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 or load 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 work function 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 reevaporate, 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.

It has already been proposed in the co-pending application Serial No. 108,062, filed on May 5, 1961, now Patent No. 3,191,076, in the joint names of Harry Huber and the applicant herein, and assigned to the same assignee, to improve this type of converter by providing an emitter

electrode constituted by a capillary body having straight channels, the interior of said converter being supplied through said channels with metallic vapor producing electrons and ions due to the ionization thereof, the mass of this body being made of a substance having a work function higher than the ionizing potential of the metal of said vapor. The metallic vapor is supplied by the surface of a liquid metal contained in a tank, and the temperature of this metal may be maintained and possibly 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.

As shown by experience, the ionization of the ionizable metal, which is produced within said capillary channels by the effect of surface ionization may be insufficient if the work function of the emitter is too small.

The object of this invention is to further improve the converter of the type defined above, so as to render the ioniaztion more effective and the operation of the converter more efficient notwithstanding the relatively small work function of the emitter.

The means provided by the present invention favor the ionization in volume of the ionizable substance on the inside of the capillary channels of the emitter in such a manner that this volume ionization effect is added to the surface ionization and thereby remedies the insufficiency thereof.

According to the present invention, a converter provided with a capillary emitter, the channels of which have at least in part a form and shape permitting the penetration of light energy from an external source, comprises means to admit this light energy into the inside of these channels in order of facilitate, thanks to the action of the photons, the ionization of the atoms of the ionizable substance by a larger quantity of particles of low energy circulating on the inside of the capillary channels.

Accordingly, it is an object of the present invention to provide a thermo-electronic converter of the type described above which eliminates by simple and effective means the afore-mentioned drawbacks and shortcomings encountered in the prior art constructions.

Another object of the present invention resides in the provision of a thermo-electronic energy converter in which the ionization of the ionizable metal is increased notwithstanding the relatievly low and insufficient value of the work function of the emitter.

Still another object of the present invention resides in the provision of a thermo-electronic energy converter which enables a considerable improvement in the output of the converter by utilizing the dual effect of surface and volume ionization.

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, one embodiment in accordance with the present invention.

Referring now to the single figure of the drawing which shows for purposes of illustration only an axial cross-sectional view through a thermo-electronic energy converter in acordance with the present invention, the converter illustrated therein comprises an emitter **1**, for example, of tungsten, realized in such a manner as to possess capillary channels **2**, for example, rectilinear capillary channels realized, for instance, by assembly of capillary tubes. One normally understands by capillary tubes cylindrical tubes or the like in which the capillary forces acting on the liquid which penetrates the same, play a preponderant role which leads in practice to a diameter generally inferior to the order of magnitude of 1 mm.

This emitter 1 is mounted in front of a transparent window 3, for example, of sapphire with respect to which the channels 2 are perpendicular. The window 3 is set into or encased in a fixed mounting 4 secured to a metallic ring 5 sealed to an insulating cylinder 6 and supporting the emitter 1 to which it is electrically connected. At the other extremity thereof, the cylinder 6 is sealed to a metallic ring 7 to which is secured a collector 8, for example, of copper. The window 3, support or mounting 4, the rings 5 and 7, the cylinder 6 and the collector 8 define a vacuum-tight enclosure which is evacuated across the pumping stem 9 cut after the operation, and placed in communication across the passage 10 provided in the mounting support 4 with a reservoir 11 of ionizable material such as cesium, carried by conventional heating means 12 at a temperature at which the cesium in the channels 2 flows in an ionized flow. The cesium vapor penetrates into the capillary channels 2 through the space between the window 3 and the emitter 1. Connections 17 and are made, respectively, with the ring 5 and the collector 8 to permit collecting the electric voltage produced by the converter.

A calorific and light flow is directed according to the arrows 19 with a slight inclination to a line perpendicular with respect to the window 3; the calorific and light flow traverses this window 3, penetrates into the channels 2, and, thanks to its slight inclination, irradiates a portion of the walls of these channels 2 in such a manner as to heat the same and produce the electron emission. At the same time, certain photons of this flow facilitate the ionization of the cesium atoms under the impact of the electrons issued from the walls or other particles circulating in the capillary channels 2. The gas flow escaping the channels 2 within the enclosure is thus substantially ionized under the dual effect of surface and volume ionization.

The converter described operates then as a usual converter but with an improved efficiency which may express itself, for example, by a relative lowering of the temperature of the emitter. This improvement is due to the excitation of the cesium atoms by photons on the inside of the capillary channels 2 of the emitter 1 in such a manner as to superpose the effects of volume and surface ionization. The output voltage is collected at the terminals or connections 17 and 18.

It should be noted that it is not indispensible for the present invention that the capillary channels 2 be rectilinear; they may, in contrast thereto, be curved or bent, provided they present to the entry of the light a portion sufficiently rectilinear in order that the light energy may penetrate the same. The structural realization comprising an assembly of capillary tubes is also not limitative of the present invention, as the desired form and shape of the channels may also be obtained in a porous body sintered in any suitable conventional manner. It is understood that converters comprising variations of this nature fall also within the frame and spirit of the present invention.

Thus, while I have shown and described one embodiment in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to a person skilled in the art, and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A thermo-electronic energy converter, comprising within an evacuated envelope: electron emissive means operative upon heating supported within said envelope, electron collecting means supporting within said envelope and electrically insulated from said electron emissive means, said electron collecting means substantially facing and spaced from said electron emissive means to define a space therebetween and made of a material having a work function lower than said electron emissive means, illumination enabling means comprising a part of said evacuated envelope, said electron emissive means being comprised of a body provided with a number of capillary channels which open at one end thereof into the space between said electron emissive means and said electron collecting means, and at the other end thereof terminate on the opposite surface of said electron emissive means and open into a second space defined by the opposite surface of said electron emissive means and said illumination enabling means, tank means containing a liquid metal having an ionizing potential lower than the work function of said electron emissive means, means interconnecting said tank means and said second space for supplying vapor from said liquid metal to the second space and thereby supply said vapor also through said channels into the space between said emissive and collecting means, said illumination enabling means serving to illuminate with visible spectrum energy the interior of said capillary channels for heating said electron emissive means to emission temperature and enhancing, by the effect of photons of said visible spectrum energy, the ionization of the atoms of said vapor.

2. The thermo-electronic energy converter according to claim 1 wherein the illumination enabling means admits the rays of visible spectrum energy in a direction slightly inclined at an angle with respect to the said capillary channels to an extent such that at least a portion of the internal walls of said channels are struck by said rays of energy thereby illuminating and heating said walls to emit electrons.

3. The thermo-electronic energy converter set forth in claim 1 wherein said illumination enabling means comprises a window transparent to light and comprising a part of the evacuated envelope, said window being spaced from and facing the opposite surface of the electron emissive means.

4. The thermo-electronic energy converter according to claim 1 wherein said illumination enabling means comprises a window transparent to light and comprising a part of the evacuated envelope, said window being spaced from and facing the opposite surface of the electron emissive means and admitting the rays of visible spectrum energy in a direction slightly inclined at an angle with respect to the said capillary channels to an extent such that at least a portion of the internal walls of said channels are struck by said rays of energy thereby illuminating and heating said walls to emit electrons.

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