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[54] **PROCESS FOR EXCHANGE OF CHARGE AND APPARATUS FOR CARRYING OUT THE PROCESS**

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[51] **Int. Cl.** **H01j 27/00**

[58] **Field of Search** 313/63, 231

[56] **References Cited**

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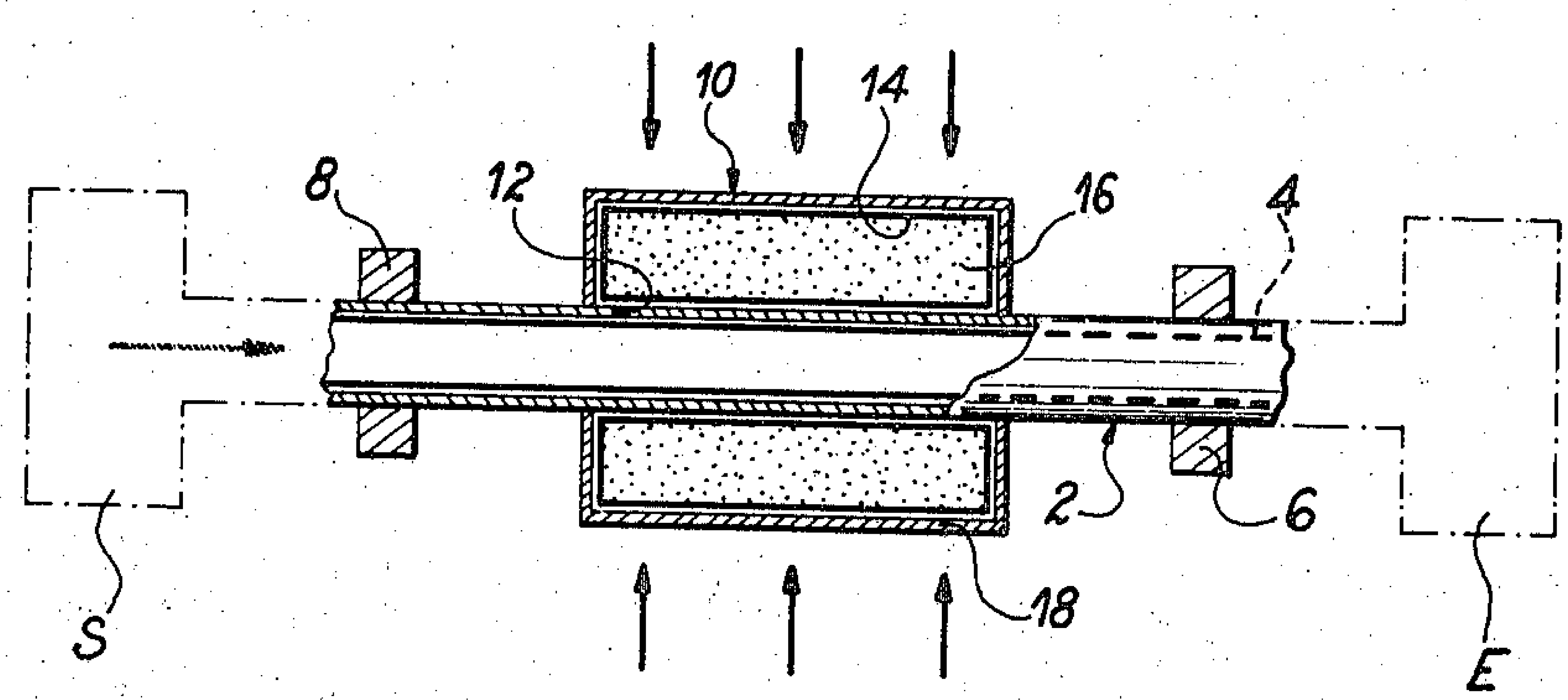
[57] **ABSTRACT**

Positive ions of a gas are charged with electrons from a metallic vapor to provide negative ions of the gas by passing the positive ions through an isothermal enclosure into contact with a metallic vapor providing electrons. The metal providing the vapor is circulated in closed cycle in the enclosure in vapor form from a hot central portion to cooler end portions thereof and in liquid phase from the end portions of the enclosure toward the central portion of the enclosure.

6 Claims, 2 Drawing Figures



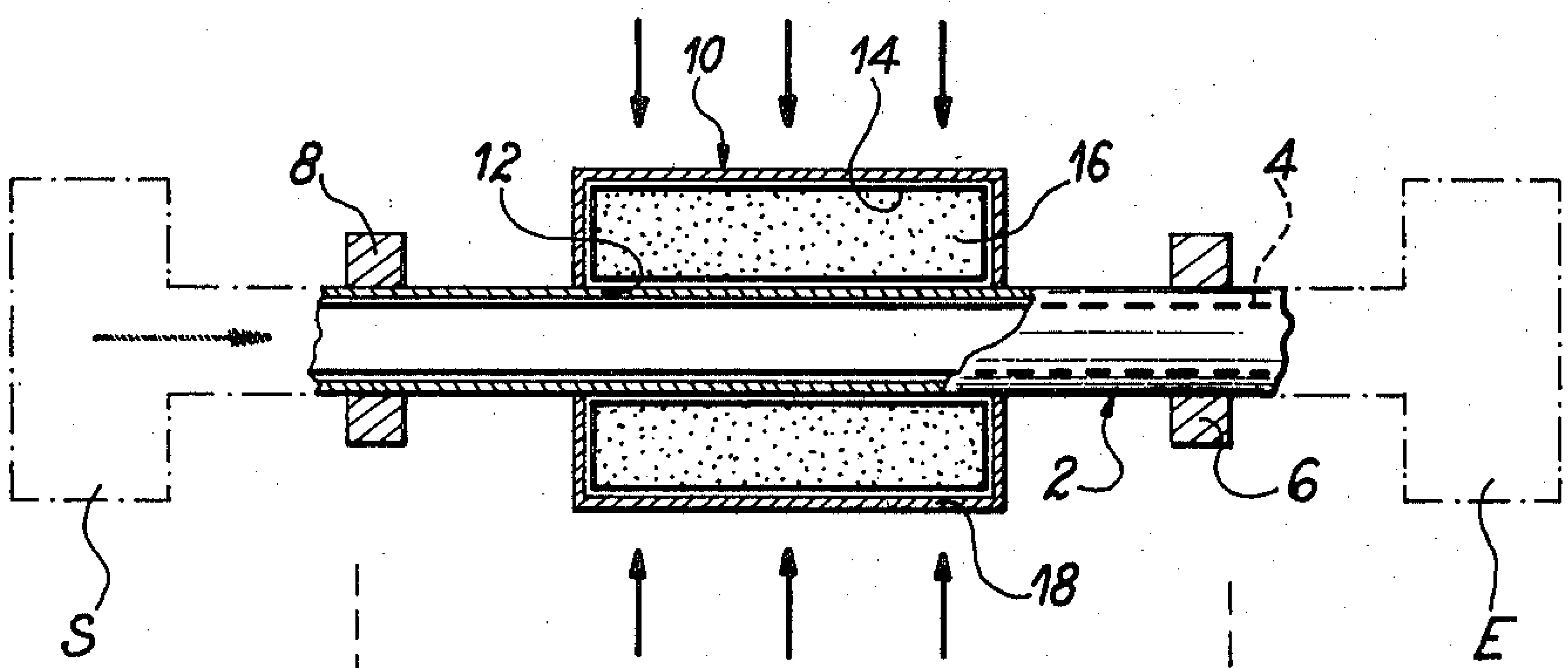


FIG. 1

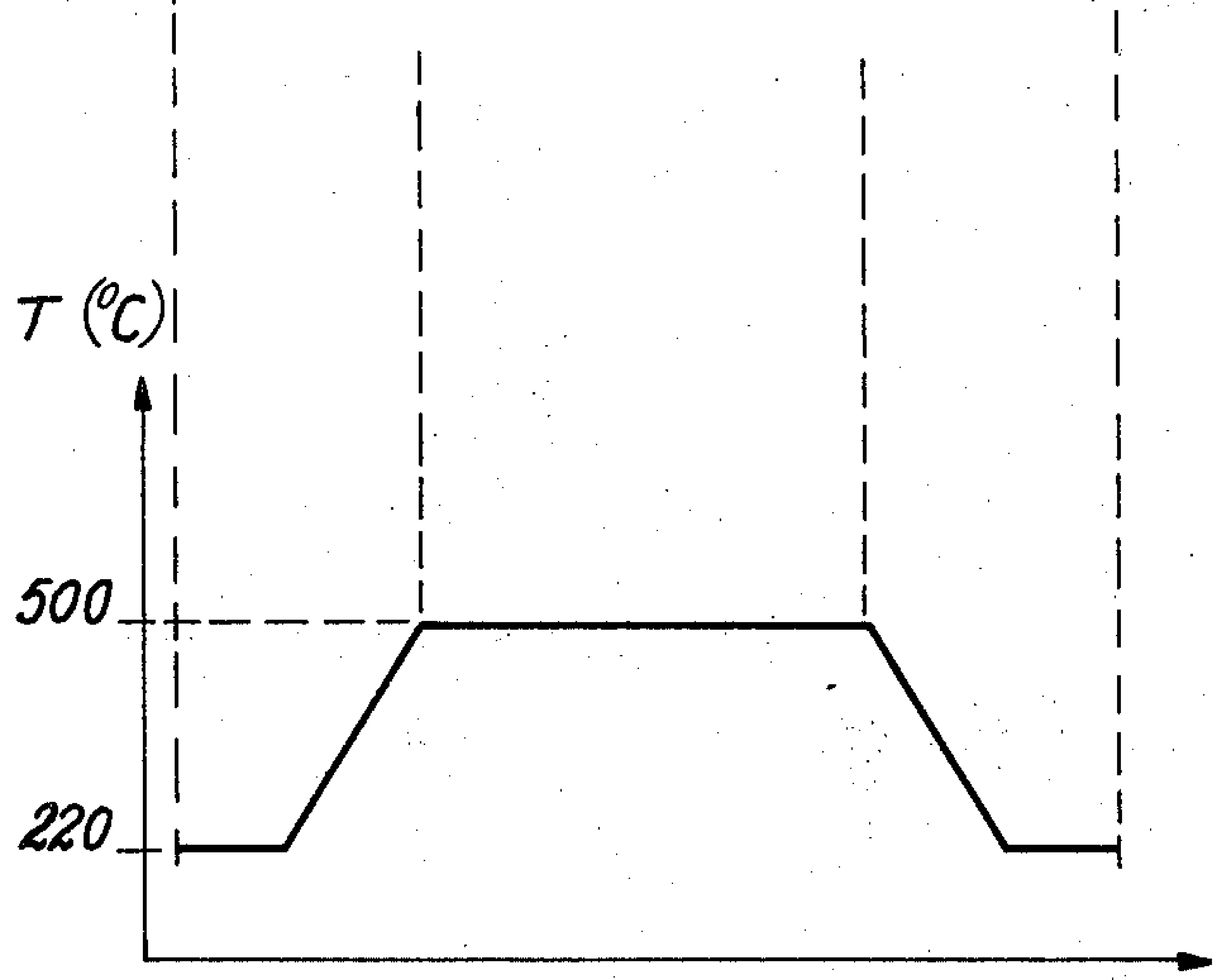


FIG. 2

PROCESS FOR EXCHANGE OF CHARGE AND APPARATUS FOR CARRYING OUT THE PROCESS

BACKGROUND OF THE INVENTION

The present invention relates to an exchange process for electric charge and apparatus for carrying out the process.

More precisely, the process fixes on positive ions of a gas, for example helium, electrons given off by a metallic vapor, for example, lithium, to obtain negative ions of the gas, this process prolonging the functional life of the apparatus carrying out the process.

Such a process is particularly useful in the case where negative ions are to be introduced into an accelerator of particles, for example, a Van de Graff Tandem under form of positive ions from a source.

In general, this exchange of charge is produced in a substantially isothermal enclosure. The enclosure contains the vapor of lithium and the flux of positive ions passes through the enclosure.

One of the principal problems resides in the fact that because of the interaction of the helium ions with the atoms of lithium, and because of the very low pressure in the accelerator there is a directed flux of lithium atoms which condenses at the exit orifice of the enclosure for the exchange of ions.

The present invention has for a specific object an exchange process of charges and apparatus for carrying it out which overcomes these inconveniences.

SUMMARY OF THE INVENTION

The present process for creation of negative ions of a gas from positive ions of the gas passes a current of positive ions from a source of positive ions through an enclosure of elongated form containing a metallic vapor susceptible of giving off electrons in which to trap the vapor in the enclosure there is created in the central part of the enclosure a hot zone and at each of the extremities of the enclosure a cold zone, the substance providing the vapor to be trapped in the enclosure being circulated in a closed cycle in vapor phase from the hot zone towards the cold zones and in liquid phase from the cold zones towards the hot zone, this last part of the cycle being actuated by capillary forces created on the walls of the enclosure.

The length of life of the apparatus is limited by the capacity of the reservoir of lithium and the losses of lithium at the entry and exit orifices, as well as by the speed of deposit of lithium at the orifices and formerly did not exceed 100 hours.

In accordance with the present invention, the lithium in vapor phase and in liquid phase circulates in the enclosure for exchange of charge in a closed cycle which provides a longer life for the apparatus.

The central region of the enclosure or exchange duct for the charge is heated to a temperature at which the desired pressure of the lithium vapor is obtained. An isothermal zone is created by heating a portion of the duct with a caloduct.

Outside of the isothermal zone, a large temperature gradient is created by adjusting the temperatures of the extremities of the exchange of charge duct to temperatures several degrees above the temperature of fusion of lithium. In this way, the condensed lithium at the extremities of the duct is in liquid phase while its vapor pressure at the extremities of the duct is quite low so that the losses of lithium at the input and output orifices is neglibile.

The liquid lithium, condensed at the extremities of the duct for the exchange of charge, diffuses from the cold extremities of the exchange duct toward the hot central zone by capillary action, the interior wall of the exchange duct being covered with a metallic mesh or wick in accordance with the present invention.

The present invention equally has for an object apparatus for carrying out this process. The apparatus is included by a tube covered on its interior surface by a metallic mesh or wick saturated with a metal which is vaporized within the tube, the tube forming the duct for exchange of charge. A hollow sleeve surrounds the tube over a part of its length and closed at its extremities, the sleeve being covered on its interior surface by a metallic mesh or wick containing a metal having a boiling temperature higher than the temperature to be obtained in the tube. This sleeve with the metallic mesh covering its interior walls forms an annular caloduct providing homogeneous heating of the central zone of the duct for exchange of charge.

There is therefore a first tube containing the metal, for example lithium, in vapor phase and partially in liquid phase. Around this first tube is disposed a closed cylindrical sleeve which forms an annular caloduct for homogeneous heating of the central zone of the tube containing lithium. The cylindrical sleeve contains a metal having an appropriate boiling temperature, for example, cesium, acting as a heating agent. The exterior wall of the sleeve acts as an evaporator and is maintained at an appropriate temperature by an exterior application of heat. The interior wall of the sleeve, that is the wall of the tube containing lithium, acts as a condensor.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWING

The present invention will be further described by the following description of a preferred embodiment of the invention which in no way limits the scope thereof. In the accompanying drawing, FIG. **1** is a cross-sectional view of an isothermal enclosure containing a vapor and heated by an annular caloduct; and

FIG. **2** is a graphic representative of the distribution of temperatures within the enclosure of FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. **1,** the enclosure includes a tube **2** preferably of stainless steel which acts as a duct for exchange of charge. It connects a source **5** of positive helium ions, of known type, to the enclosure E for utilization of negative helium ions, this enclosure preferably being a Van de Graaff cell. Tube **2** is covered on its interior surface with a mesh or wick **4** preferably of stainless steel. At each extremity of tube **2** and outside of the tube are located two heaters **6** and **8,** these heaters being any suitable means providing an adequate adjustable temperature. Over the central part of tube **2** is secured a sleeve **10** closed at its ends. The interior wall **12** of sleeve **10** coincides with the exterior surface of tube **2.** Sleeve **10** is preferably of stainless steel. Sleeve **10** is covered on its interior surface by a mesh **14** preferably of stainless steel. When in operation, sleeve **10** is evacuated and filled with a cesium vapor **16.** Cesium, having a boiling temperature of 670°C. can be replaced by other metals to obtain other temperatures in tube **2**. For example, potassium can be used having a boiling temperature of 880°C.

The exterior wall **18** of sleeve **10** is heated as shown in FIG. **1** by the arrows. The source of this heat can be radiation, induction, or by any other appropriate means. Exterior wall **18** acts as an evaporator for the cesium contained in sleeve **10** while the interior wall **12** of the sleeve acts as a condensor. A uniform temperature is thus provided in all portions of tube **2** surrounded by sleeve **10**. The range of temperatures obtained in the portion of tube **2** surrounded by sleeve **10** depends on the source of heat and on the metal utilized in sleeve **10**. Outside of this zone there is a temperature gradient as seen in FIG. **2**, the abcissa representing distance and the ordinant representing the temperatures.

In the region of tube **2** surrounded by sleeve **10** the temperature is uniform and the pressure of the lithium vapor is identical at every point in this region of tube **2**. This is an important characteristic of the apparatus and may be critical in the case where the thickness of the gaseous metallic target should be known.

The lithium atoms tend to leave the hot zone and locate on the walls of tube **2** close to its extremities. By capillary action created by mesh or wick **4** which covers the interior of tube **2**, this deposit of lithium is forced toward the hot zone of tube **2**. Stoppage of tube **2** is thus prevented. It is essential that the temperature of operation of heaters **6** and **8** be greater than the temperature of fusion of the metal to be vaporized even though quite close to it, so that the capillary forces can occur.

The functioning of the embodiment of FIG. **1** is apparent from the above description. Lithium is charged into tube **2**. Sleeve **10** is partially filled with cesium. A source of heat is applied to sleeve **10** as indicated by the arrows. Cesium evaporates on wall **18** of the sleeve at the contact of the source of heat. Cesium vapor condenses on the interior wall **12** of the sleeve and supplies heat to the central zone of tube **2**. Condensed cesium is directed toward wall **18** of sleeve **10** because of mesh **14** through capillary action. The lithium under the action of this transfer of heat vaporizes in the central zone of tube **2**. The apparatus is then ready for use since it is in communication with the source of ions S and enclosure E of the accelerator. The flow of positive ions passing through the lithium vapor captures electrons and the ions become negative. The lithium vapor follows the described cycle between the hot central zone and the cold zones at heaters **6** and **8**.

When the lithium vapor is used for exchange of charge, the temperature of operation of the central zone of tube **2** is 500°C. In this case, heaters **6** and **8** operate at 220°C.

The present invention is not limited to the use of lithium as the gaseous metallic target for exchange of charge of helium ions. Lithium can be replaced in tube **2** by another metal such as cesium, potassium and sodium. With these other metals, the operational temperature would be selected by variation of heat flux applied to the evaporator of the annular caloduct that is sleeve **10**, and by suitable choice of the heat transfer

agent of the caloduct such as water, cesium, potassium and sodium.

Further, the helium positive ions can be replaced by positive ions or fast atoms of any other element for which negative ions or fast atoms are desired by exchange of charge.

The present invention is not limited to the preferred embodiment described above and shown in the drawings. Variations in this concept come within the present invention. In particular, isothermal enclosures can be used other than the exchange duct for the charge of a Van de Graaff Tandem. The invention can, for example, be used in the measurements of atomic and ionic collisions, in nuclear fusion research and in reactors with nuclear fusion.

We claim:

1. Process for creation of negative ions in a gas from positive ions in the gas comprising the steps of passing a current of positive ions from a source of positive ions through an elongated enclosure containing a metal providing a metallic vapor capable of giving off electrons, trapping the vapor in the enclosure by creating in the central part of the enclosure a hot zone and by creating at each extremity of the enclosure a cold zone, causing the metal whose vapor is trapped in the enclosure to circulate in a closed cycle in vapor phase in the hot zone toward the cold zones and in liquid phase in the cold zones toward the hot zone, and causing circulation from the cold zones toward the hot zone by capillary forces created on the walls of the enclosure.

2. Process as described in claim **1**, the cold zones being maintained at a temperature slightly greater than the temperature of fusion of the metal providing the vapor in the enclosure.

3. Apparatus creating negative ions in gas from positive ions in the gas comprising a tube, a metallic wick covering the interior surface of said tube saturated with a metal to be vaporized and maintained within said tube, a source of positive ions, an enclosure for utilization of negative ions, said tube connecting said source and said enclosure, a caloduct comprising a hollow sleeve surrounding and extending over a part of the length of said tube and closed at its ends, a metallic wick covering the interior surfaces of said sleeve and containing a substance having a boiling temperature greater than the operating temperature of said tube and having at the operating temperature a vapor pressure sufficient for the correct functioning of the caloduct and means at each extremity of said tube for maintaining the extremities of said tube at a temperature slightly higher than the temperature of fusion of the metal to be maintained in said tube.

4. Apparatus as described in claim **3**, said means at each extremity of said tube being a heater on the exterior wall of said tube.

5. Apparatus as described in claim **3**, the substance within said sleeve being selected from the group consisting of water, cesium, sodium, potassium and lithium.

6. Apparatus as described in claim **3**, the metal in said tube being lithium, said tube, said sleeve and said metallic wicks being stainless steel.

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