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METHOD AND APPARATUS FOR PRODUCING AN ELECTRICALLY CONDUCTIVE PARTICLE BEAM IN A CONTAINER UNDER VACUUM

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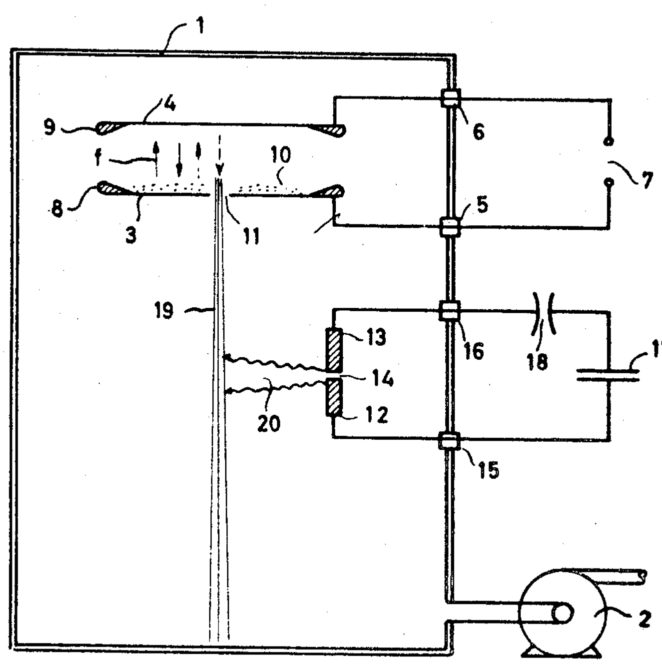

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1

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METHOD AND APPARATUS FOR PRODUCING AN ELECTRICALLY CONDUCTIVE PARTICLE BEAM IN A CONTAINER UNDER VACUUM

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ABSTRACT OF THE DISCLOSURE

A method and apparatus for producing an electrically conducting beam of particles by applying a high electric voltage between two electrodes for electrifying powdered particles contained therebetween and for ejecting the said particles through a central aperture in one of the electrodes, and by irradiating the ejected particles with an electromagnetic wave source whose frequency corresponds to the one having the maximum absorption by the particles.

The instant invention relates to a method and an apparatus for producing, in a container under vacuum, an electrically conductive particle beam.

In numerous scientific and industrial applications it is necessary to produce, in an enclosure under vacuum, a particle beam whose form, electric conductivity, density, chemical and isotopic composition must have predetermined values.

Particularly, for absolute densities of the order of 1 g./cm.^{3}, this beam may be obtained from the substance under study in the solid state if the thermodynamic conditions corresponding to this state are satisfactory; for absolute densities small than 10^{-10} g./cm.^{3}, the rectilinear beams may be obtained by means of molecular beams.

Between these two limits, a supersonic gaseous jet may be used the length of which before collapse is rigidly limited as it is practically impossible to obtain a Mach number greater than about 10 and the absolute density of which may only be small in view of the limited pumping speed of the vacuum pumps evacuating the system. It is also possible to use a number of fine solid or liquid particles in which case the desired absolute density is obtained by a judicial choice in the dimension and the concentration of the particles.

Particle beams having a density located between 10^{-10} and 10^{-6} g./cm.^{3} have been obtained or ways to obtain them suggested, by the condensation of a gas as it passes through a cooled nozzle followed by a separation of the mixture gas-droplets, the jet of droplets then forming said particle beam of a mean density of 10^{-10} to 10^{-9} g./cm.^{3}. Such particle beams may also be obtained by condensation of a gas on ionized centers followed by shooting of the gas-droplet mixture and then separation of the gas from the droplets, the jet of droplets forming the particle beam which has a mean absolute density of between 10^{-10} and 10^{-6} g./cm.^{3}.

Belgian Patent No. 611,449 has already been granted on a "Methode pour produire des faisceaux rectilignes de matiere a l'interieur d' un espace ferme au sein duquel regne unvide pousse" (Method for Producing Rectilinear Beams of Matter Inside a Closed Space Under High Vacuum).

It is an object of the present invention to widen the scope of the absolute density of these particle beams and to make them conductors of electricity; particularly, the invention relates to the production of conducting beams having an absolute density smaller than about 10^{-4} g./cm^3.

According to the invention, a method of producing

2

an electrically conductive particle beam under vacuum consists in spreading the material which will constitute the beam in the form of a powder on a conducting electrode, in subjecting the said powder to an electrical field produced by the application of an electrical voltage between the electrode carrying the powder and a second electrode whereby the action of the field causes movement of the electrified powder grains in such a way as to eject them from between the electrodes, in irradiating the powder grains by means of electromagnetic waves the frequency of which corresponds to maximum absorption of the waves by the powder grains whereby the action of the waves produces almost instantaneous volatilization of the grains and ionization of the material which thus becomes electrically conductive.

The ejection of the powder between the electrodes may also take place through an opening in one of the electrodes.

Ionization of the material may be increased by allowing an auxiliary electric current to flow through the particle beam.

Again in accordance with the invention, a device for the production of an electrically conducting particle beam comprises a tight enclosure and pumping means connected thereto to create a vacuum; at least two conducting electrodes wherein one has an area adapted to support a powder of the material which will constitute the beam; these electrodes being connected to a high voltage electric source and being provided with means to throw the electrified powder grains inwardly of the space between the electrodes; the electrode which carries the powder having a substantially central aperture for the discharge of the electrified powder grains; and means to create an intense electrical arc inside the said enclosure adjacent the passage of the electrified particles.

A specific, although non-limitative, embodiment of the invention will now be described with reference to the annexed drawing containing a single figure which is a transverse cross-sectional view of an apparatus for the production of an electrically conductive particle beam according to the invention.

The drawing illustrates a tight casing or enclosure **1** placed under vacuum by a vacuum pump **2**. Casing **1** contains two flat electrodes **3** and **4** facing two tight and insulating passages **5** and **6** for connections joining plates **3** and **4** to a high voltage source **7** of, for instance 2×10^4 volts. Electrodes **3** and **4** are provided with convex peripheral rims **8** and **9** the purpose of which is explained below. The lower electrode **3**, over which the powder **10** to be ionized is spread, is provided with a central aperture **11**. The powder may, for instance, be grains of lithium aluminum hydride ($LiAlH_4$) having a diameter of 10^{-3} cm.

Adjacent the axis of aperture **11** is mounted a pair of electrodes **12**, **13** made of aluminum for instance, as this metal is included in the powder. Means is provided for the projection of an arc **14** between electrodes **12** and **13**, the arc having a very high intensity as, for instance, 2×10^4 amps. The arc is energized through two tight and isolating passages **15**, **16** by the discharge of a condenser **17** the circuit of which is closed by a spark-gap **18**. Condenser **17** has a capacity of the order of one microfarad and is loaded under a voltage of approximately 20 kilovolts. Energization of arc **14** under vacuum is obtained by emission of cold electrons.

The operation of the device is as follows: the powder grains **10** loaded by contact with electrode **3** are attracted by the other electrode **4** over which they change their polarity and rebound. A stationary condition prevails wherein, at each moment, the number of particles which come down per unit of time is equal to that which rises (see arrows *f*). Rims **8** and **9** of the electrodes electrostatically and mechanically push back in the space between the electrodes the particles which would tend to escape from the ends.

Finally, the descending particles escape through the aperture **11** and constitute the rectilinear jet **19**. The intense radiations **20** emitted by arc **14** volatilize and ionize the jet—formed by a constellation of insulated powder grains—thus transforming it into an electrically conducting beam in such a brief period of time that the gaseous diffusion has not sufficient time to destroy the beam.

The invention finds numerous applications in the field of research: The particle jet obtained may be used in the feeding of fusion nuclear reactors, for propulsion and compression of magnetic fields of great intensity, for the production of the UH radio frequencies, in plasma guns, in spacial propulsion, etc. The industrial applications are equally quite interesting; it is used for high voltage switches, high current switches and high speed switches.

It is to be understood that the invention is not limited to the embodiment which has just been described but also comprises various modifications such as, for instance, curving of the path of the particle jet **19** by subjecting it to the action of an auxiliary electric field in the case where a non-rectilinear beam is required.

We claim:

1. A method for producing an electrically conducting beam of particles in vacuum which comprises spreading a powder of particles made of the material which is to constitute the beam on a first horizontal conducting electrode having a small aperture therein; subjecting the said powder to an electric field produced by applying an electrical voltage between the said first electrode carrying the powder and a second electrode whereby action of this field moves the electrified particles between the electrodes and ejects them through the said aperture; irradiating the ejected particles by means of electromagnetic waves the frequency of which corresponds to the

frequency of the waves having the maximum absorption by the particles, whereby the action of the waves produces an almost instantaneous volatilization of the particles and ionization of the material so that it becomes electrically conducting.

2. A method according to claim **1**, wherein ionization of the material is increased by subjecting the beam of particles to an auxiliary electric current.

3. An apparatus for the production of an electrically conducting beam of particles comprising:

(a) a tight enclosure;
(b) means connected to said enclosure for creating a vacuum therein;
(c) at least two horizontally spaced conducting electrodes having facing surfaces, the lower electrode having a small aperture therein;
(d) a powder of particles made of the material which is to constitute the beam, spread over the lower electrode;
(e) a high voltage source for providing an electric field across the electrodes and for ejecting the electrified particles through said aperture; and
(f) a high intensity electromagnetic wave source within said enclosure for irradiating the ejected particles, the frequency of the said wave corresponding to the frequency of the waves having the maximum absorption by the said particles.

4. An apparatus as claimed in claim **3**, comprising a rim on the edge of each electrode to prevent escape of the particles.

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