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APPARATUS FOR UNIFORM VAPORISATION OF HIGH MELTING MATERIALS IN PARTICULAR QUARTZ

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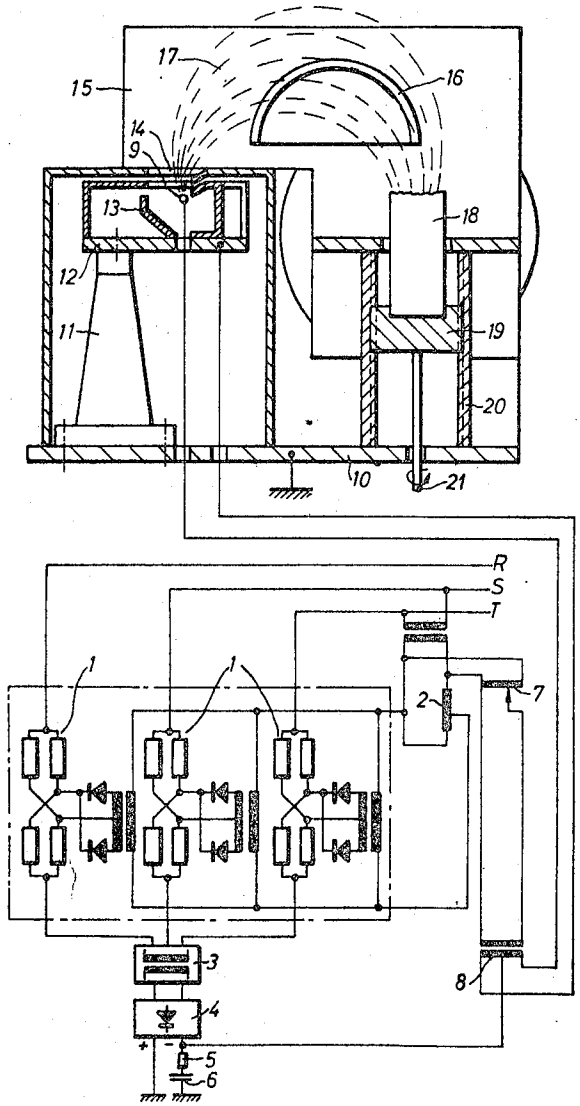

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APPARATUS FOR UNIFORM VAPORISATION OF HIGH MELTING MATERIALS IN PARTICULAR QUARTZ

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ABSTRACT OF THE DISCLOSURE

Control elements in the primary winding of the special high voltage supply unit to maintain constant output power from the power supply for the operation of electron guns used to vaporize quartz for deposition in the vaporized phase upon synthetic resin surfaces including an apparatus to maintain the quartz or inorganic material surface to be vaporized in the same position in relation to the focus of electron beams from the electron gun and to continuously keep the angle of vaporization constant by the rotating movement of the inorganic or quartz material, a rate at which the material is consumed for vaporization.

The invention relates to an apparatus for the uniform vaporisation and application of high melting materials, in particular quartz in a high vacuum to synthetic resin surface in which is provided a source emitting a beam of electrons, and having magnetic focussing, a support for the material which is vaporised at the focal point of the electron beam, and a high voltage supply apparatus to produce the electron beam.

Such apparatuses are used for vapour phase deposition of coatings on articles for surface finishing. To obtain a uniform coating and compact adherence, it is absolutely essential for the material to be vaporised completely uniformly.

In known apparatuses, a power supply unit supplying direct voltage, as far as possible free from ripple voltages, is used for the source of electrons for producing the electron beam. The disadvantage of such a supply unit is that when quartz is vaporised, dissociation takes place, owing to excessively high local temperatures obtained in the quartz by excessively sharp focusing. The rate of vaporisation also depends to a major extent on the body which is being vaporised. The body usually used has hitherto been located at the focal point of the electron beam and into which a furrow was burnt. As a result, there was a constant change in the angle of vaporisation which in the ideal case should be 180° in order to ensure uniform rate of vaporisation. This resulted in a non-uniform layer of deposited vapour being obtained, which layer was subject to powerful mechanical stresses and had poor adhesion and insufficient hardness. These disadvantages can only be avoided if care is taken to ensure that the rate of vaporisation is kept as constant as possible throughout the vaporisation time by keeping the temperature at the focus and the vaporisation angle of 180° unchanged.

According to the invention, this is achieved by arranging automatically and continuously operating control members such as thyristors, transducers or electron tubes, into the primary winding of the high voltage supply unit in order to maintain at a constant value the output voltage required for vaporisation, and by inserting the material to be vaporised into a rotatable and at

the same time axially displaceable support which continuously keeps the material in the focus. The control members constantly keep the output at the same level so that at the high voltage end the same energy is constantly available for the source of the electron beam, and overloading and damage of the power supply unit is impossible. It has proved to be particularly advantageous if the high voltage side of the supply unit carries a high voltage that is rich in ripple voltages since this measure, surprisingly, has a particularly advantageous effect on focussing and hence vaporisation. The voltage peaks in the high voltage cause immediate recommencement of vaporisation if, during one half wave, the current has exceeded the permissible level due to excessive vapour pressure, and in the next following half wave the output has been diminished by the cut in control by means of the continuously operating output control member. In the half wave following this cut in control the peak, which is rich in ripple voltages occurs owing to the cut in control and again causes recommencement of vaporisation of the quartz, which acts as insulator. Since this entire process takes place within 3 to 4 half waves, the quartz is unable to cool during this brief time, in contrast to the phenomena which have been observed with the power supply units hitherto used. This results in a completely uniform rate of vaporisation.

The body which is to be vaporised is preferably cylindrical and is advantageously kept vertical with its upper end surface permanently situated at the focal point by means of the feed device constantly moving the body forwards in a spiral movement. According to the invention, the focus is so adjusted that the diameter of the focus is equal to the radius of the body being vaporised and extends unilaterally from the centre of the end surface to the edge of that surface. This shape and arrangement of the body to be vaporised ensure, together with the control members of the power supply unit, very uniform vaporisation and an angle of vaporisation which can always be kept at approximately 180°.

The invention will now be described diagrammatically with reference to the accompanying drawing.

The phases R, S, T of a power supply unit lead to control members which are in the form of transducers **1**, the transmittance of which is controlled by an auxiliary transformer **2**. The transducers **1** are connected to a transformer **3** which has a voltage of, for example, 380 volts at the input end but 10 kv. at the hight voltage end, with which an earthed rectifier **4** is connected in series. A smoothing resistor **5** and smoothing condenser **6** serves to filter off part of the high-ripple voltage. The main component of the source of electrons is a cathode **9**, the heating of which is controlled by an auxiliary transformer **7** via a transformer **8**. The source of electrons further comprises an earthed plate **10**, an insulator **11** which is constructed as a support, a shield **12**, a focussing cup **13** and an auxiliary anode **14**. A permanent magnet **15** with magnetic yoke **16** deflects and focuses the electron beam **17** obtained in such a manner on to a quartz rod **18** which is to be vaporised, and which serves as anode so that the focus extends from the centre of the quartz rod **18** to a point on the edge of the rod. The quartz rod **18** is mounted in an externally screw threaded support **19** which is continuously moved upwards in a screw threaded tube **20** by a drive **21** at a rate corresponding to the rate of vaporisation.

I claim:

1. In combination with an apparatus and three-wire, three-phase power source of the type wherein a high voltage supply unit, means for emitting a beam of electrons, means for focussing the beam of electrons, and means for positioning an object at the focal point of

the beam of electrons are provided for uniform vaporization of high melting temperature materials in a high vacuum and uniform deposition onto synthetic resin material surfaces, the improvement which comprises:

a circuit for detecting short-circuiting conduction paths in the highly electrically conductive state of vaporized material by means of controlling impedance for increasing and decreasing potential to the high voltage supply unit;

means for applying a large potential with minimal current when direct current potential momentarily decreases, thereby re-instituting the electron beam after direct current discontinuance because of short-circuited interruption drawing down direct current potential below firing potential level; and

a device for simultaneously rotating and axially displacing the material to be vaporized onto the synthetic resin material, said device disposed to hold one surface of the material to be vaporized in the same plane containing the focal point of the applied electron beam, and the axially displaceable rate of travel for maintaining this position being dependent on the amount of vaporized material and the vaporization rate, thereby the angle of vaporization is kept constant at approximately 180 degrees as the material is vaporized.

2. Apparatus as claimed in claim 1, wherein said circuit for impedance control comprises:

a transformer with primary windings connected between two of the phases of the three-wire, three-phase circuit conductors, so that the same voltage is coupled to said isolation transformer secondary windings, for electrically isolating the power source;

a variable-position autotransformer with primary windings connected in parallel with secondary windings of said isolation transformer, so that the same voltage is applied to the primary windings of said variable-position autotransformer, for stepping-down voltage and stepping-up current applied to the primary windings of said autotransformer;

a fixed-position autotransformer, with primary windings connected in parallel with the secondary windings of said isolation transformer so that the same voltage is applied to the primary windings of said fixed-position autotransformer, for stepping down voltage and stepping-up current applied to the primary windings of said autotransformer; and

a cathode-heater transformer with primary windings connected in parallel with the secondary winding portion of primary windings of said variable position autotransformer so that the same voltage is applied to said cathode-heater transformer, said cathode-heater transformer secondary winding being center-tap connected to the direct current potential output of the high voltage supply unit, superimposing thereon an alternating-current potential output of said variable-position autotransformer for supplying power to the electron beam emitting means, the alternating current potential output portion being used to heat the cathode, wherein by a sudden electrical discharge the voltage decreases towards zero until the electron beam is interrupted whereupon the means for controlling impedance reduces the potential drop to the high voltage supply unit allowing maximum potential to be developed for application to the electron beam emitter means within one cycle permitting vaporization and deposition to be uniform.

3. Apparatus as claimed in claim 1, wherein said impedance control means comprises:

at least one transducer connected between one phase output of the three-wire, three phase power source and one input to the high voltage supply unit for increasing or decreasing the resistance in the conductor for providing greater or lesser power feedback control;

a transformer with primary windings connected between two of the phases of the three-wire, three-phase circuit conductors so that the same voltage is coupled to said isolation transformer secondary windings for electrically isolating the power source;

a fixed-position autotransformer, with primary windings connected in parallel with the secondary windings of said isolation transformer so that the same voltage is applied to the primary windings of said fixed-position autotransformer, for stepping down voltage and stepping-up current applied to the primary windings of said autotransformer;

a second transformer, with primary windings connected in parallel to the secondary winding portion of the primary windings of said fixed position autotransformer so that the same voltage is applied to the primary windings of said transformer, said transformer coupled electromagnetically to said transducer; and

means for rectifying the alternating-current output of said transformer and applying the direct current to said transducer for increasing or decreasing the flux reluctance in said transducer, the change of flux reluctance resulting during a half cycle of the sinusoidal input of one phase of the three-phase input to the high voltage supply unit whereby the change in flux reluctance causes a change in power control in the one phase conductor to the high voltage supply unit.

4. In combination with an apparatus and three-wire, three-phase power source of the type having a high voltage supply unit for producing a high direct current potential, means of emitting a beam of electrons, means of focusing the electron beam and support means for holding material at the focal point of the electron beam for uniform vaporization and application of high melting temperature materials in a high vacuum onto synthetic resin material surfaces, wherein the improvement comprises:

a transformer with primary windings connected between two of the phases of the three-wire, three-phase circuit conductors so that the same voltage is coupled to said isolation transformer secondary windings for electrically isolating the power source from interference by any subsequent circuitry;

a fixed position autotransformer, with primary windings connected in parallel with the secondary windings of said isolation transformer so that the same voltage is applied to the primary windings of said fixed-position autotransformer, for stepping-down voltage and stepping-up current applied to the primary windings of said autotransformer;

three transducers inserted between each phase of the three-phase power source and the high voltage supply unit having three input connections, one for each of the three-wire, three-phase conductors;

three transformers, with primary windings of each connected in parallel to the other and to the second winding portion of the primary windings of said fixed-position autotransformer so that the same voltage is applied to the primary windings of said three transformers, one each of said three transformers coupled electromagnetically into said transducers;

means for rectifying the alternating current output of said three transformers and applying the resulting direct current through said transducers thereby controlling the impedance presented by said transducers between the three-phase power source and high voltage supply unit during one-half cycle;

a variable-position autotransformer, with primary windings connected in parallel with secondary windings of said isolation transformer so that the same voltage is applied to the primary windings of said variable-position autotransformer, for stepping-down voltage and stepping-up current applied to the primary windings of said autotransformer; and

a cathode-heater transformer with primary windings connected in parallel with the secondary winding portion of primary windings of said variable-position autotransformer so that the same voltage is applied to said cathode-heater transformer secondary windings being centertap connected to the direct-current output of the high voltage supply unit superimposing thereon an alternating-current output of said variable-position autotransformer for supplying current to the electron beam emitting means with regard to several break downs in a few seconds of the electron beam by electrical discharges in the vacuum during evaporation, the breakdown and immediately following reignition, will cause an output with a maximum peak voltage five to ten times greater than the mean voltage level, whereby the electron beam emitting means is constantly and continuously refired within one cycle after shorting during the vaporization state when the material is electrically conductive, reducing reignition time to within one cycle as vaporization and deposition of high melting temperature materials takes place.

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