United States Patent

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[73] Assignee **European Atomic Energy Community Brussels, Belgium**

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[33] **Belgium**
[31] **50663**

[54] **PROCESS AND DEVICE FOR DEPOSITING ON SURFACES**
6 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **204/298,** 204/192
[51] **Int. Cl.** **C23c 15/00**
[50] **Field of Search** 204/192, 298

[56] **References Cited**

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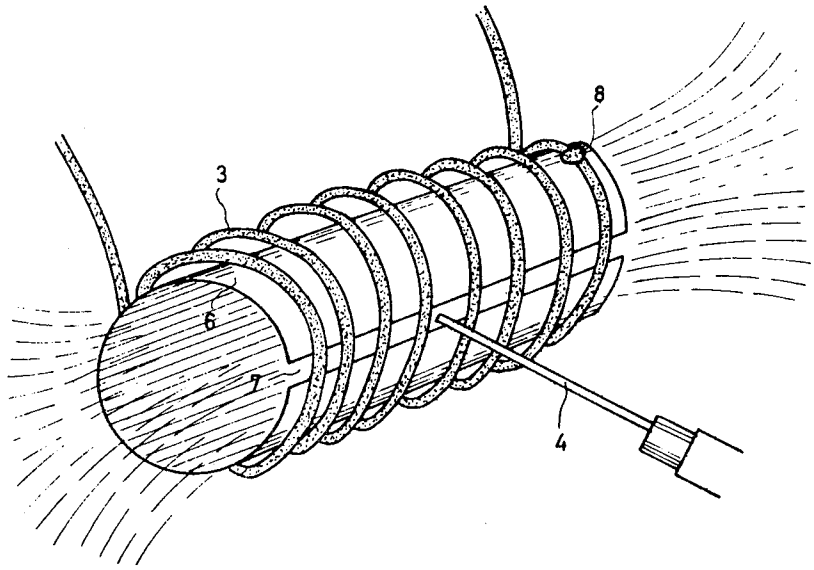
ABSTRACT: Apparatus for depositing a thin layer of a conducting or partially conducting material on the surface of a body which includes a vacuum chamber, a high-frequency coil located within the chamber for generating an electromagnetic field and means for supplying gas into the chamber in the vicinity of the electromagnetic field. A substantially tubular wall, which may be in the form of a cylinder or a truncated cone, is disposed within the high-frequency coil and electrically connected thereto. The tubular wall is slit from end to end to prevent heating by direct induction with a consequent reduction in the formation of the plasma and lowering of the efficiency of the coating operation.



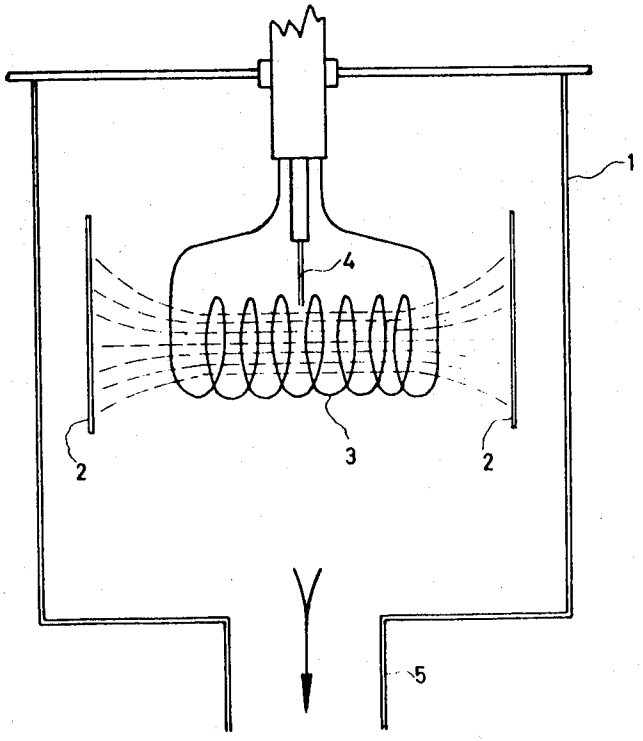


FIG.1

FIG.2

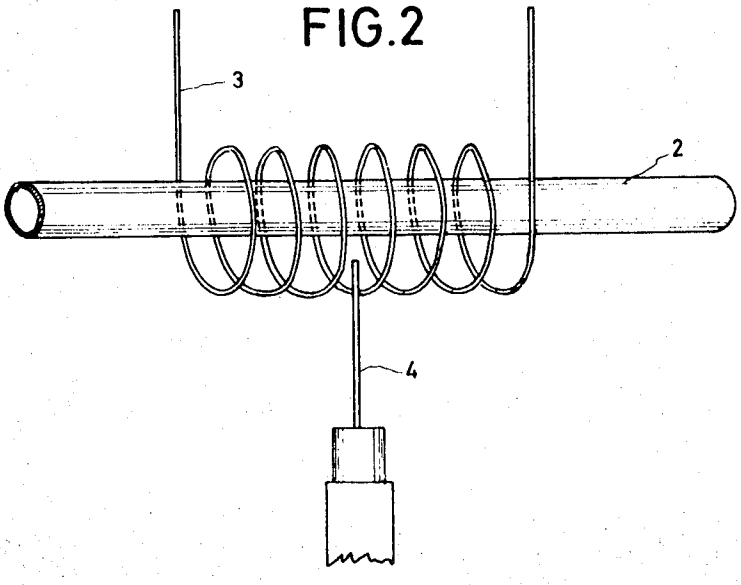
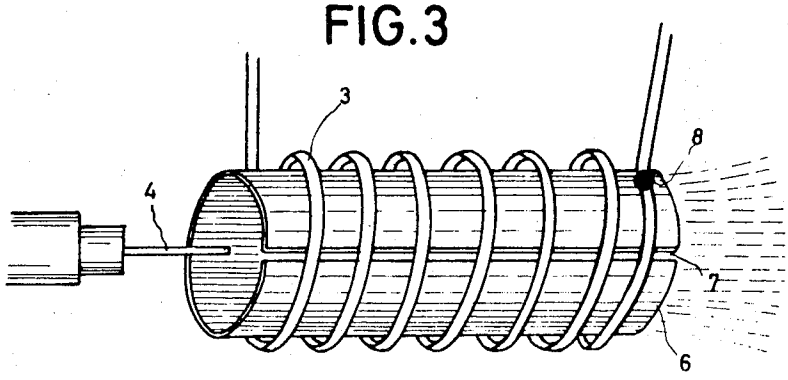


FIG.3



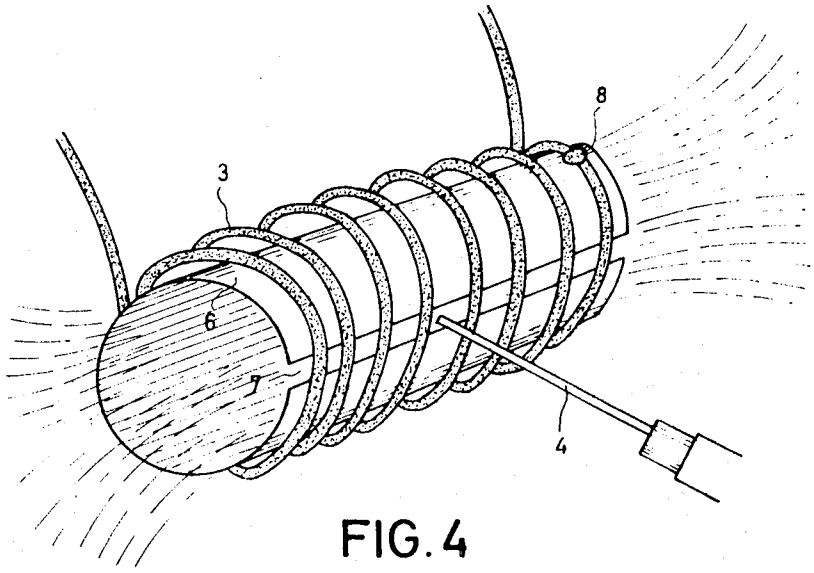


FIG.4

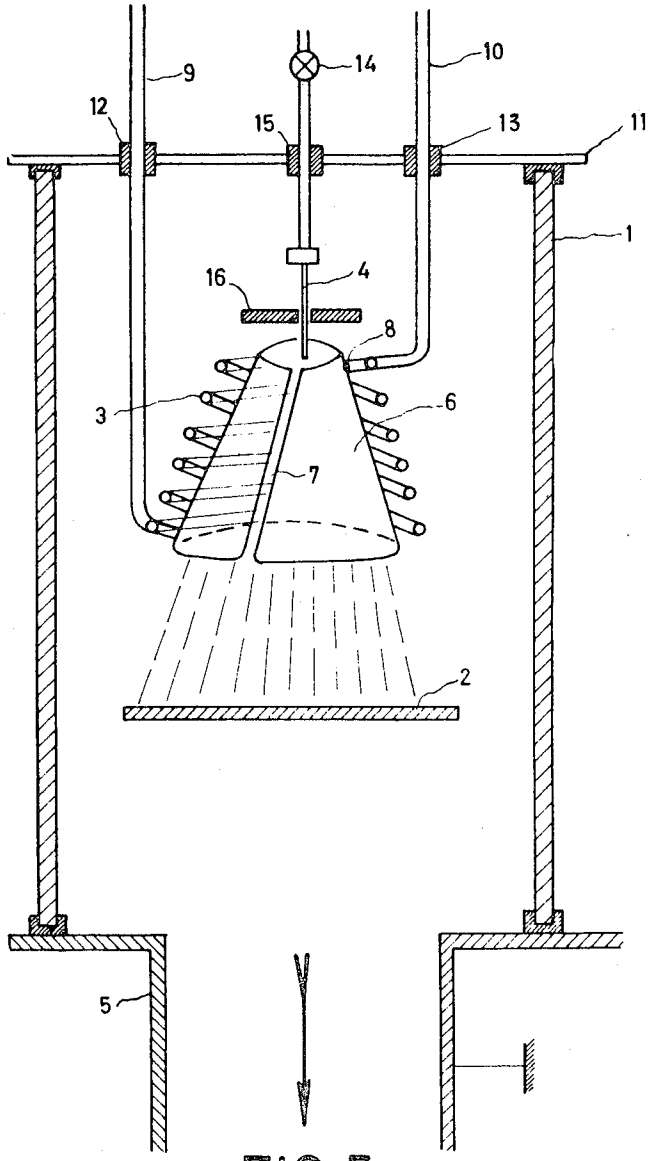


FIG. 5

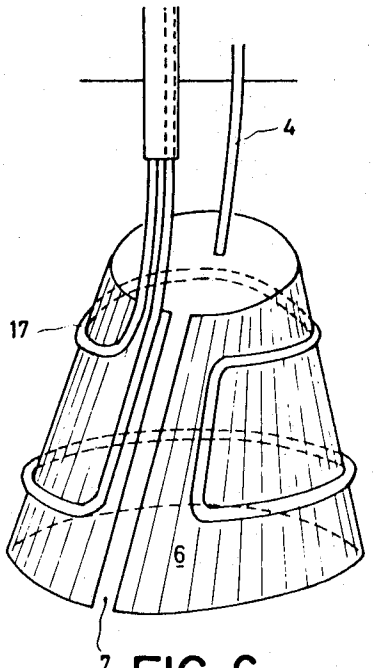


FIG. 6

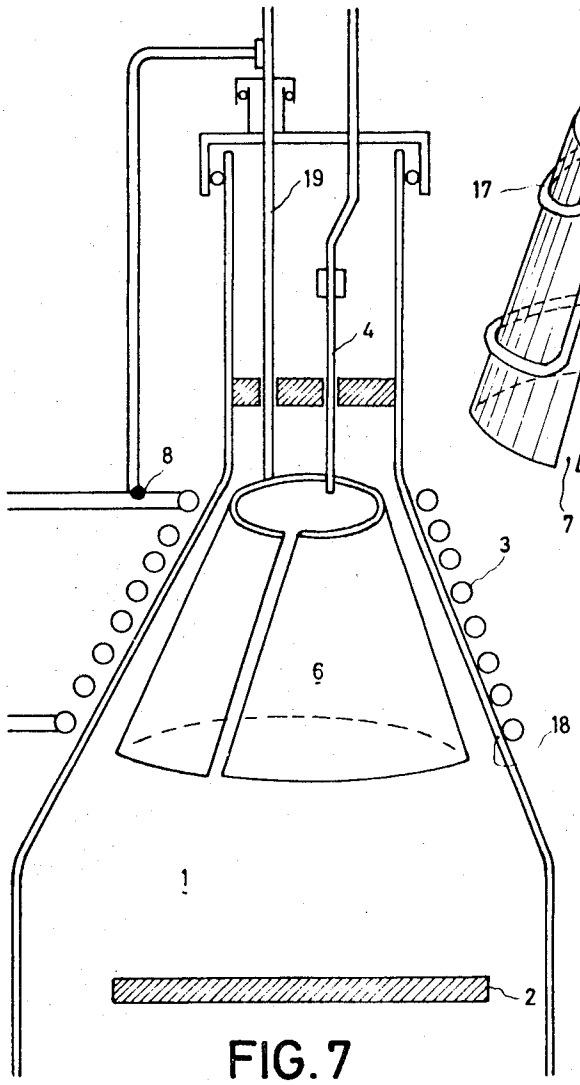


FIG. 7

PROCESS AND DEVICE FOR DEPOSITING ON SURFACES

The invention relates to a process and apparatus for coating surfaces and to improvements in or modifications of the invention forming the subject of specification No. 39140/66 (Belgian Specification No. 673939). Specification No. 39140/66 describes a process and an apparatus for depositing on surfaces of all kinds coats of metals or alloys (intermetallic compounds), graphite and all types of conductors or partial or semiconductors. These coats may cover metal, ceramic or plastics surfaces, in the form of noncorrosive protective layers or in the form of a diffusion barrier inside or outside any object, or form electrically conductive or heat-conducting coatings, or coats applied for the purpose of decoration or their appearance. It is possible in carrying out the invention to apply coatings which are conductive or which are compounds not necessarily themselves conductive but having at least one conductive component.

According to this process, the surface to be coated is immersed in a gaseous atmosphere which is constantly renewed and kept at a substantially constant low pressure, this gas being subjected to a high-frequency high voltage electromagnetic field by applicator means that are immersed in the gaseous atmosphere and are made, at least in part, of the material to be deposited or one of its components, so as to ionize the gas and convert it, at least in part, into plasma, whose particles, owing to their agitation, strike the means or part thereof aforesaid for the application of the high-frequency field and tear off them, as a result of the shock produced, small particles of material which, according to whether the gas is inert or reactive, are deposited unchanged or after combination with the gas on the surface to be coated.

The apparatus or device for implementing this process is extremely simple. It comprises essentially a vacuum chamber in which are placed the article to be covered, a high-frequency coil made of the material to be deposited and a conduit for supplying gas, opening in the proximity of the coil.

Although this system for covering surfaces operates effectively, attempts have been made to increase its efficiency, and the present invention, in fact, relates to improvements in this process and apparatus or device.

According to the invention, a wall formed of the material to be deposited and slit from end to end is disposed within the means for producing the high-frequency field and is connected to it electrically.

The form of this wall plays, of course, an important part. In the simplest embodiment it is cylindrical and slit along a generatrix.

In a more elaborate embodiment, it is in the form of a truncated cone and also slit along a generatrix. In this case the coil surrounding it is also in the form of a truncated cone, i.e. the diameters of its turns vary to produce a conical formation of the coil.

The injection of the neutral gas, which normally takes place at one end of the coil, may, in the case of the cylindrical wall, be effected at the center of the slit and thus produce spraying in two opposite directions, at both ends of the coil.

The material to be deposited being supplied mainly by the wall disposed within the coil, the latter may be made of a metal that conducts electricity well, for example copper, which can, if desired, be covered with the material to be deposited. Thus, in the case of expensive deposits such as gold, the cost of the coil is reduced, and the few particles that are torn form its surface do not introduce impurities into the deposit produced.

The advantages of the invention consist in greater efficiency of the system. The metal to be deposited is ejected in a preferential direction, enabling the deposit to be "localized" better and losses through the turns of the coil to be avoided; this is particularly advantageous when precious metals, such as gold, platinum or iridium are being deposited. Quite a thick intermediate wall (a few millimeters) may be used, thereby permitting very long metallization times without its being necessary to open the apparatus and break the vacuum. This is very advantageous in the case of a large series of operations. Furthermore, some materials (in particular sintered metals) are much more readily obtainable in the form of sheets than wires.

Various nonlimitative examples, of the process and apparatus according to the invention will now be described with reference to the accompanying drawings and with comparison with examples according to Specification No. 39140/66.

FIGS. 1 and 2 are diagrams showing embodiments of the system according to Specification No. 39140/66.

FIGS. 3 and 4 are diagrams of embodiments of this invention,

FIG. 5 is a section through a spraying apparatus according to this invention,

FIGS. 6 and 7 show variants for the assembly of the conical intermediate wall.

The figures only show the elements necessary for an understanding of the invention, the corresponding elements of these FIGS. having identical reference numerals.

FIG. 1 shows a variant of the spraying system described in Specification No. 39140/66. A vacuum chamber 1 receives the articles 2 to be covered. A high-frequency coil 3 made of the material to be sprayed and a conduit 4 for supplying gas having its opening in the proximity of the coil, in this case at its middle, is located within the chamber I. A pipe 5 is connected to a vacuum pump (not shown).

FIG. 2 shows another variant of the system according to Specification No. 39140/66. To cover an elongated article such as a tube 2, it is introduced into the high-frequency solenoid 3.

FIGS. 3 and 4 are diagrammatic views of embodiments of the present invention. Within the high-frequency coil 3 there is disposed a wall 6 made of the metal to be sprayed. This wall is slit from end to end at 7 and is connected electrically to the coil at 8, for example by a spot weld or solder. The neutral gas is introduced through the tube 4.

The apparatus operates as follows. In the normal operating conditions, plasma forms within the wall 6, and the atomized metal can only escape through the ends of this tubular wall. This results in better directing of the beam and therefore better localization of the deposit produced.

It is essential for the wall to be connected electrically to the coil and for it to be slit from end to end. Otherwise it would be heated by direct induction, and the formation of the plasma would be reduced thereby reducing the efficiency of the operation to an unacceptable value. This wall acts as an electromagnetic-field concentrator with respect to the high-frequency coil.

FIG. 5 shows a complete spraying unit according to the invention. It shows the vacuum chamber 1, the article 2 to be covered, the high-frequency coil 3, the conduit 4 for supplying the gas, the pipe 5 leading to the vacuum pump (not shown), and the intermediate wall 6 slit from end to end at 7 and connected electrically at 8 to the coil 3.

This arrangement has two special features. Firstly, the coil 3 and the intermediate wall 6 made of the material to be deposited have a conical shape, which increases the spraying efficiency. Secondly, the top portion is easily dismountable; the high-frequency connections 9 and 10 pass through the cover 11 of the vacuum chamber 1 in insulators 12 and 13. Similarly, the gas inlet 4, provided with a metering valve 14, passes through the cover 11 in an insulator 15. A deflector 16 prevents particles from being flung upwards.

The induction coil 3 may be made of copper, for example, which is covered with a layer of the metal to be projected if it is an expensive metal such as gold. Thus the particles torn from the surface of the coil do not impair the purity of the deposit coming mainly from the wall 6.

In the case of metals having low melting points, the conical wall 6 must be cooled for example by means of a tube of the same material, such as 17 in FIG. 6.

FIG. 7 shows another variant of the apparatus according to the invention. The conical wall 6 is separated from the induc-

tion coil 3 by a quartz wall 18, but it is still connected to it electrically at 8. In this case the coil is outside the vacuum chamber 1, which limits to one 19 the number of electric conductors entering the vacuum chamber.

We claim:

1. Apparatus for depositing a coating on a surface, which apparatus includes a vacuum chamber to receive the surface to be coated, means for producing a high-frequency electromagnetic field within the chamber and means for introducing gas into said chamber in the vicinity of said electromagnetic field, wherein the improvement comprises a substantially tubular wall formed of the material to be deposited and disposed within said chamber and within said electromagnetic field, said wall being slit from end to end, and means for electrically connecting said wall to said field producing means.

2. Apparatus for use in depositing a thin layer of conducting or partially conducting material on a surface of a body, which apparatus includes a vacuum chamber for receiving said body, a high frequency coil for generating an electromagnetic field located within said chamber and a conduit for supplying gas in the vicinity of said electromagnetic field, wherein the improvement comprises a substantially tubular wall formed of the material to be deposited and disposed within said high frequency coil, said wall being slit from end to end, and means for electrically connecting said wall to said high frequency coil.

3. Apparatus as claimed in claim 2, wherein the high-frequency coil, is made of a metal that is a good conductor, and the surface of the coil is covered with the same material as that which is to be deposited.

4. Apparatus as claimed in claim 2, wherein the wall is cylindrical and is slit along a generatrix thereof.

5. Apparatus as claimed in claim 2 wherein the wall is in the form of a truncated cone and is slit along a generatrix thereof.

6. Apparatus as claimed in claim 5, wherein the high-frequency coil, is made of a metal that is a good conductor, and the surface of the coil is covered with the same material as that which is to be deposited.