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PROTECTIVE PLATING FOR ELECTRODES

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FIG. 1

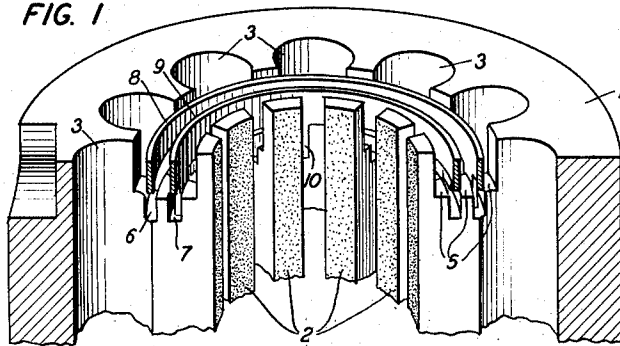


FIG. 2

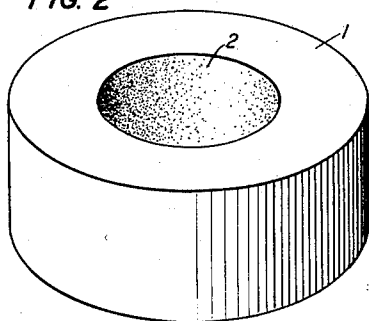


FIG. 3

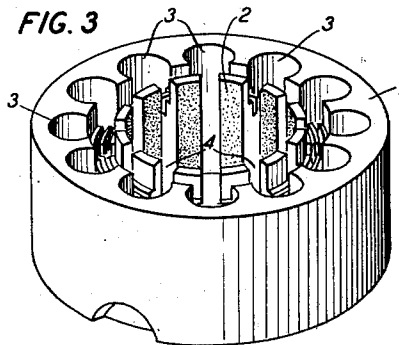


FIG. 4

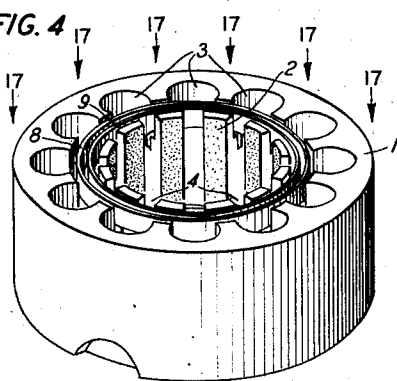
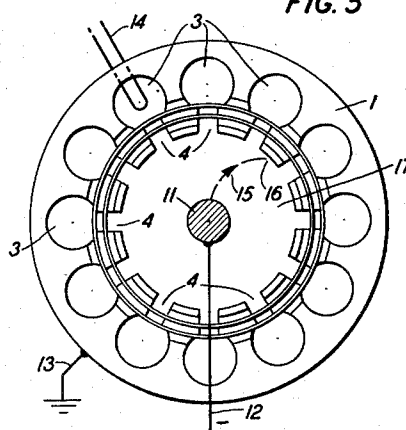


FIG. 5



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PROTECTIVE PLATING FOR ELECTRODES

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4 Claims. (Cl. 250—27.5)

1

This invention relates to discharge devices and is specifically directed to protection for electrodes of such devices in which said electrodes are subject to bombardment by electrified particles which may in turn cause disintegration of the bombarded surfaces of said electrodes.

Such electrodes as are subject to said bombardment are normally required to dissipate by radiation or by conduction or by both the heat generated by such bombardment and, of course, heat produced therein by other means during normal operation of such a device. Said electrodes are required also to be conductive electrically since some are employed as actual electrical circuit paths for electron flow while others are employed primarily as structures responsive to nearby acceleration of electrified particles but are nevertheless subject to unintentional collision therewith and collection thereon of some of said particles, disposal of which particles is necessary to prevent accumulation of undesirable space charges or electrostatic charges on such structures. A typical examples of the latter is the well-known magnetron cavity type anode.

In order to combine good electrical and thermal conductivity with refractory properties, and since these two groups of characteristics do not exist in practical ratio in any one known material, prior art has found it advisable and necessary to employ as electrode material such materials as iron and copper and the noble metals and various well-known alloys of these types. These materials have practical values of thermal and electrical conductivity for the various uses made of same. It is well known that such materials as indicated and others of like character and use not specifically mentioned do not possess the required refractory properties to withstand bombardment without attendant injurious disintegration.

This deficiency has been recognized heretofore and the problem has been met in a number of ways in a number of special instances. For the condition wherein the electrode is not required to dissipate a large quantity of heat, pure refractory metals such as silicon, tungsten, molybdenum, etc., or alloys thereof have been used as the basic electrode material. However, in cases where such electrodes have been required to have a rather high thermal conductivity, refractory materials obviously could not be used as the basic electrode material. Nevertheless, such materials having properties similar to those of molybdenum or tungsten have been finely

2

powdered and applied to electrodes made of less refractory material such as iron, copper, etc., by means of a binder of, for instance, pure silica.

Somewhat similar to the latter arrangement and also heretofore known is the use of a sheet or ribbon of pure molybdenum, or material of similar refractory characteristics, as a lining or covering for electrode surfaces such as those of a magnetron anode which is subject to bombardment. Such linings or coverings have been held to the protected electrodes by mechanical means such as press fits or resilience of the lining or coating or by means of special configuration of the surface to be lined or covered which held the material in place. The art is lacking in respect to disclosing the application of plated layers of such pure refractory materials as molybdenum, tungsten, or the like to electrode bodies of high electrical and thermal conductivity. A device enclosing electrodes so treated will have the obvious advantages of both an electrode body of high thermal and electrical conductivity and also of refractory surface character to inhibit disintegration thereof by electron bombardment and a strongly adherent condition between the body and the surface material. The prior art does not teach such an adherent relationship between such bodies and previously mentioned types of surface layers for same.

It is the object of this invention to provide electrodes whose body material is of low refractory nature and of high electrical and thermal conductivity, with a strongly adherent plated surface layer thereon of metal having characteristics similar to those of molybdenum or tungsten. This latter type of metallic material is recognized as having good refractory characteristics capable of inhibiting disintegration of electrode surfaces which are covered therewith and which are bombarded by electrified particles.

As an exemplary disclosure, the invention may be explained in connection with a magnetron anode of the multicavity type employed in high frequency generation. The anode is in the form of a toroid having equally spaced cavities formed in the inner wall of said toroid and completely through the thickness of same. Each cavity has an opening into the inner space of the toroid. Between the said openings of adjacent cavities are portions of the inner surface of the toroid. It is upon these latter portions that the plating of molybdenum or tungsten or the like is used. The energized filament of the magnetron is

axially located within the inner space of the toroid such that by location of a suitable magnetic field acting substantially parallel to said filament as is well known, said filament emits electrons which accelerate in spirals past the said cavity spaces to excite said cavities for generation therein of high frequency electrical energy.

The electrons so accelerated by the anode voltage and the axial magnetic field have occasion to impinge upon the exposed inner toroid surface portions which separate respective cavity openings. It has been found, and is well known, that the body of the magnetron, usually made of copper, will disintegrate injuriously under such bombardment unless the said magnetron is properly aged. The expression "aged" is well known in the art to designate a process whereby magnetrons and other discharge devices of like character and function are specially processed prior to use to enable same to withstand rigorous operating conditions such as heavy loads of current or excessive heat or bombardment of surfaces by electrified particles, among various other such conditions.

If the bombarded anode surface of such a magnetron is plated with a thin strongly adherent layer of, for instance, molybdenum, the aforementioned aging process is not necessary to prevent disintegration of the anode surfaces, which usually results in operation at the wrong frequency, if at all, and with loss in power extractable therefrom.

The manner of obtaining this thin strongly adherent plating of molybdenum or like material is in brief depositing same on the surface to be plated by decomposition of a gaseous carbonyl of the plating material at the said surface. One apparatus and procedure which may be used to so plate magnetron anodes in accordance with the invention is disclosed in a copending joint application of L. H. Germer and G. E. Reitter, Serial No. 653,868, filed March 12, 1946. Any disclosure of this aforementioned application dealing with production of a magnetron anode plated with a layer of molybdenum, tungsten, or the like is an exemplary disclosure of the present invention and the Germer-Reitter disclosure of such production referred to is considered as incorporated in this disclosure as if fully included herein.

Following is a detailed description of the invention and is set forth in connection with the attached drawings of which the following are general descriptions.

Fig. 1 illustrates in perspective and in section a completed magnetron anode of the multicavity type provided with the invention;

Fig. 2 illustrates in perspective an unmachined anode block after having been treated in accordance with the invention;

Fig. 3 is an illustration in perspective of the anode block of Fig. 2 subsequent to machining of same;

Fig. 4 shows a completed anode in perspective and subjected to a magnetic field; and

Fig. 5 is a plan view of such a magnetron anode as is shown in Fig. 4 and diagrammatically indicates electrical connections thereto to illustrate subsequent detailed description concerning the utility of the invention.

In Fig. 2 is illustrated a toroidal block 1 of copper having its inner surface 2 plated with a thin layer of pure refractory metal such as molybdenum. Molybdenum is indicated as a

specific material suitable for this application but the invention is intended to cover other such metallic plating materials having refractory characteristics similar to those of molybdenum or tungsten as related to their ability to inhibit disintegration thereof by bombardment of same by electrified particles and their ability as thin layers not to detract substantially from the electrical and thermal conductivity properties of the body upon which they are plated.

In Fig. 3, the block 1 of Fig. 2 has been machined to produce therein an even plurality, namely, twelve, of equally spaced cavities such as 3 extending the full thickness of the block 1. Fig. 5 shows more clearly the angular relationship between these cavities 3. Slots 4 are machined in the wall separating the cavities from the inner space of the toroidal block. It is well known that the size of the block 1, of the cavities 3 and of any other holes, slots, ridges, etc. associated with these cavities will affect the frequency of the energy generated from a magnetron containing this well-known type of anode structure and that consequently the machining operations referred to herein should be precise in accordance with well established practices in the art.

As illustrated best in Fig. 1 a circumferential slot 5 is machined in both ends of the block 1 and in the bottom of this slot 5 are machined two additional narrower slots 6 and 7 radially separated from each other. The sequence of machining slots 4 through 7 is not fixed but preferably is in the order of slots 5, 6 and 7 and then slots 4. This order lends to facility of machining but is not mandatory. Into these slots 6 and 7 are inserted respective rings 8 and 9, preferably made of silver. Ring 8 for instance is used to interconnect or strap alternate cavities by having lugs thereon attached to the connecting wall between adjacent cavities at every other cavity. Ring 9 is used to interconnect or strap the remaining group of alternate cavities by means of similar lugs, one of which is designated 10 in Fig. 1. Such strapping of alternate cavities in general is well known to stabilize the operation of such magnetron anodes and the specific manner of so doing which is shown here is fully disclosed in the copending application of J. B. Fisk, Serial No. 529,619, filed April 5, 1944.

Fig. 4 as briefly described previously, shows a completed magnetron anode embodying the invention. All through the previous machining and fitting operations the thinly plated layer 2 of molybdenum has been retained on whatever remained of the inner surface of the original toroidal block 1 of Fig. 2. In Fig. 4 the silver rings 8 and 9 are shown assembled or fitted into their respective narrow slots 6 and 7 in the larger circumferential slot 5 as more clearly shown in section in Fig. 1. The arrows 17 are intended to illustrate that a magnetic field 17 is to be applied to the magnetron anode area in substantially an axial direction thereto as is well known in operation of such a device.

With reference to Fig. 5, a plan view of such a magnetron anode as shown in Fig. 4, the body 1 of the anode is grounded at 13, the filament 11 is connected to a negative potential 12, the magnetic field 17 is substantially perpendicular to and into the drawing and an output loop 14 is attached to one of the cavities 3. All of these features of Fig. 5 are conventional. I have illustrated the path 15 of an electron which is permitted to bombard the anode surface 2 at area

16 within the evacuated inner anode space. The manner in which such a magnetron functions to permit high frequency energy to be withdrawn by means of loop 14 is sufficiently well known that description of such operation is unnecessary for the purpose of explaining the present invention.

If the surface 2 of the anode block 1 were not coated with a thin plating of, for instance, molybdenum or other similar metal in accordance with the invention and if the magnetron diagrammatically represented in Fig. 5 were not aged, then repeated bombardment of the anode surface 2 would cause disintegration of the copper which in itself is a poor refractory material. Copper is chosen for such magnetron anodes because of its ability to conduct heat and electricity rapidly. A purpose of the invention is to protect this desirable body material with a thin layer of highly refractory material which will adhere strongly to the copper body and prevent deterioration of the surface 2 by bombardment while at the same time not affecting appreciably the substantial thermal or electrical conductive properties of the main body of copper. It is, of course, intended that the disclosure of copper in this exemplary embodiment of the invention does not preclude within the scope of the invention the use of other anode or electrode body materials such, for instance, as iron or silver or alloys of any of these singly or in combination.

Such layers of refractory material as the prior art teaches, such as powdered metal bonded with silica or pure refractory metals in the form of ribbons or strips mechanically fixed to said body members, are not considered as strongly adherent in that they may be removed entirely or in part by vibration and shock or other conditions and cannot represent as close a mechanical, electrical and thermal union as a plated layer. In addition, a plated layer, and probably equally well a ribbon or strip as previously mentioned, presents a more complete and effective refractory barrier or protector for the body material. A plated layer performs all the functions of the prior art coatings or layers and in addition provides a reliably strong adherent condition not found in the art.

An apparatus exemplary of the type suited to production of this plating of molybdenum or tungsten on such a magnetron anode as is disclosed herein is fully disclosed in the aforementioned copending application of Germer and Reitter. This apparatus employs the principle of decomposition of a metallic carbonyl at the surface, such as 2 on the drawing, to be plated. The application of such a plating to the surface of an electrode subject to bombardment, such as the magnetron anode disclosed herein, prior to machining of such a structure if same is required, results in an article of manufacture or of structure not heretofore known.

In the Germer-Reitter application is disclosed a supply reservoir in the form of an elongated closed tube which may be loaded with a large number of articles, this reservoir being then attached to the plating chamber by gas-tight means; a closed gas-tight receptacle is provided and also attached to the plating chamber by gas-tight means; the entire apparatus is then evacuated; the articles to be plated are fed one by one through a heating element heated to a desired temperature, then fed into a zone to which the plating gas is supplied to them while they

are maintained in a heated condition; and after being plated upon the desired surface they are ejected into the receptacle. After the entire number is finished the plated articles may be emptied from the receptacle and a new supply placed in the supply reservoir and the operation repeated.

In plating magnetron anodes by the above type of apparatus in accordance with the present invention, the object is to plate the internal surface of the toroidal-shaped blocks to a maximum extent with little or no plating upon other surfaces. This object is accomplished by the invention of Germer and Reitter. Exposing the desired surface or surfaces to a carbonyl of the particular refractory metal to be used as the plated layer and carefully controlling and regulating temperatures before and during the exposure will produce a strongly adherent plating in accordance with the present invention. A more detailed disclosure of the above briefly described apparatus for producing structure according to the present invention will be found in the above-referenced application of Germer and Reitter.

It is, of course, obvious that the plating arrangement disclosed herein with reference to a magnetron anode may be applied by modification thereof to other types of electrode structures such as anodes of glass or metal enclosed vacuum tubes from which anodes considerable heat dissipation is required and which are subject to injurious bombardment of electrified particles, electrons or otherwise. It is not intended that the scope of the invention shall be limited to the specific type of anode used as the exemplary disclosure since it is apparent that the invention contemplates equivalent structures wherein use of the invention is for the purposes disclosed and claimed herein. Furthermore, the invention may be used in connection with anodes which are not necessarily required to dissipate large amounts of thermal energy. In the latter case the thinness of the plated layer becomes of prime importance so as not to detract too effectively from the conductive properties of such electrodes. The thickness or thinness of such plated layers are controllable by means of the apparatus and procedure disclosed by Germer and Reitter, supra.

What is claimed is:

1. A magnetron anode of the multicavity type having a copper body, a working surface of said body having thereon a thin strongly adherent plated layer of a metal selected from the group consisting of molybdenum and tungsten.

2. A magnetron anode of the multicavity type having a toroidal copper body the inner working surfaces of the said toroidal body having thereon a thin strongly adherent plated layer of a metal selected from the group consisting of molybdenum and tungsten.

3. The process of making a magnetron anode of the multicavity type consisting of producing a solid toroidal block of copper, plating the inner surface thereof with a thin strongly adherent layer of a metal selected from the group consisting of molybdenum and tungsten and subsequently machining said block to form cavities therein spaced from each other circumferentially of said block and to form openings from said cavities to the inner space of said block.

4. A magnetron anode of the multicavity type having a toroidal copper body, said body having flat end surfaces and having cavities therein almost totally enclosed laterally by said body and

extending between said end surfaces thereof and extending symmetrically along a circular parameter of said body, said body also having slots therein, each slot extending between said end surfaces and between a different cavity and the inner space of said toroidal body, the working surfaces of said anode body bounding the periphery of said inner space and separated from each other by said slots having thereon a thin strongly adherent plated layer of metallic molybdenum.

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