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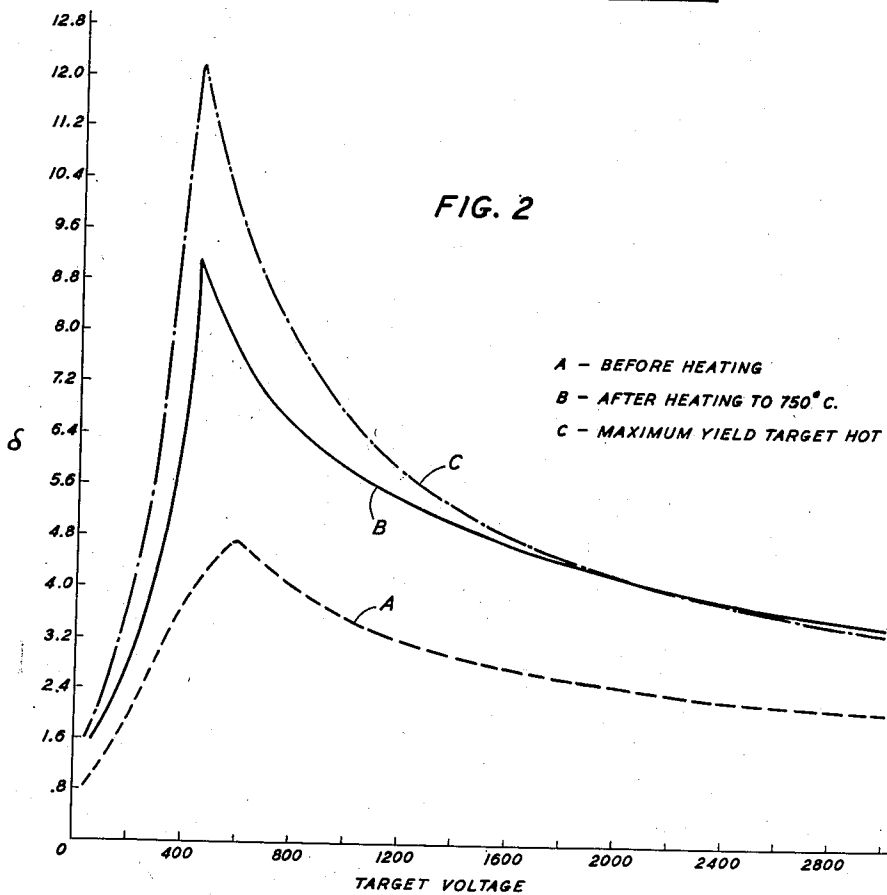
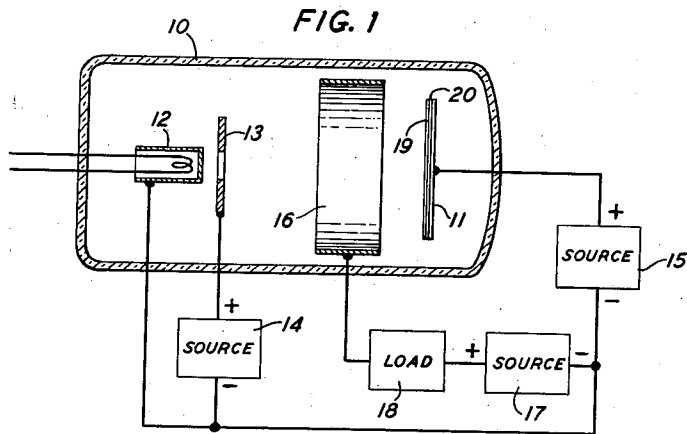
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SECONDARY ELECTRON EMISSIVE ELECTRODES

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

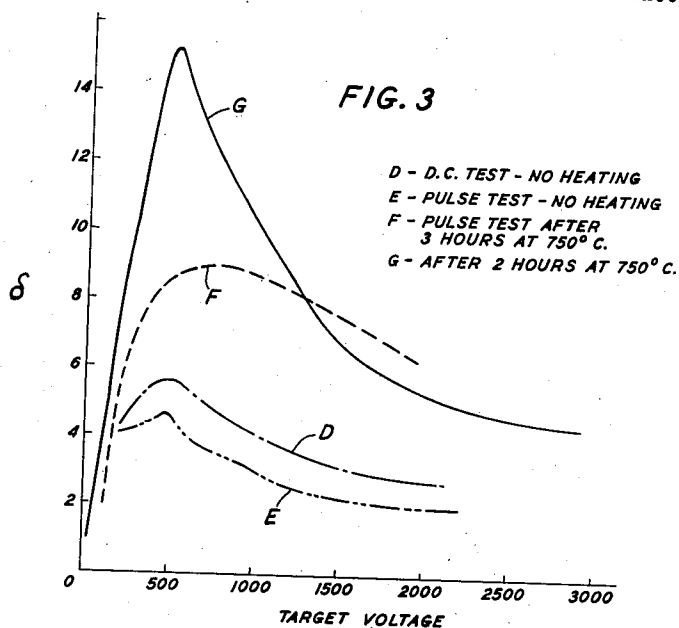


FIG. 4

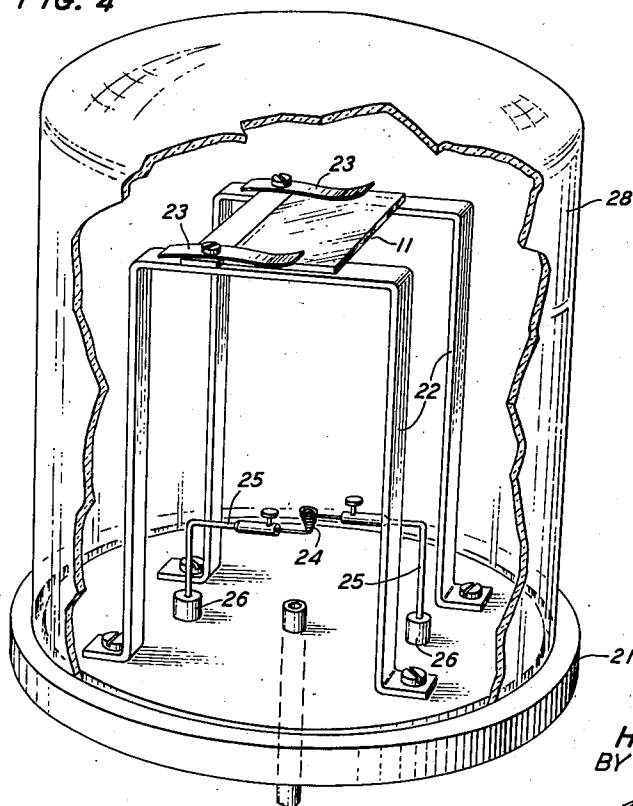
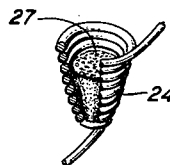


FIG. 5



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SECONDARY ELECTRON EMISSIVE ELECTRODES

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This invention relates to secondary electron emissive electrodes and to methods of making such electrodes.

A general object of this invention is to improve electron discharge devices utilizing one or more secondary electron emissive target electrodes. More specifically, objects of this invention are to increase the stability and operating life of the secondary electron emissive electrodes, to obtain large secondary emission ratios, and to produce a surface in which secondary emission occurs only during the time a primary current is impinging upon said surface.

It has been found that a layer of beryllium on an insulator coated surface of a metal will upon heat treatment produce a high ratio of secondary emission. More specifically, it has been found that if a metal is coated with a very thin layer of an insulating material, and the insulating material is coated with a very thin layer of beryllium, then heat treatment of such a composite unit will produce a surface having a large secondary emission ratio. By proper correlation of the thickness of the insulating coating and beryllium coating, and time and density of heat treatment, secondary emission ratios within prescribed ranges of values can be obtained.

In one embodiment of this invention, a target electrode, also referred to hereinafter as a "unit," comprises a thin layer of silica upon a tantalum base and a thin layer of beryllium upon the layer of silica. The layer of silica is from 50 to 5000 angstroms thick and the layer of beryllium can be in the order of 10 per cent to 90 per cent transmission thickness. The term "10 per cent transmission thickness" means that the beryllium is thick enough to obstruct the passage of 90 per cent of the light rays impinging thereon, measured by photoelectric cells. Heating such a structure at about 750 degrees for approximately 30 minutes or more will produce a secondary emission ratio of about 9 with a primary electron voltage of about 450 volts.

In another embodiment of the invention, the target electrode comprises a layer of silica upon a platinum base, and a layer of beryllium upon the silica. With an approximately 10 per cent to 90 per cent transmission layer of beryllium and a 50 to 5000-angstrom thick layer of silica, a heat treatment for two to three hours at 750° C. will produce a surface having a secondary emission ratio of over 14, when a primary electron voltage of about 500 volts is used.

Similar secondary emission ratios may be obtained by the use of insulators other than silica and by the use of bases other than tantalum or platinum.

The invention and the various features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings, in which:

Fig. 1 is a diagram of an electron discharge device illustrative of those in which target electrodes constructed in accordance with this invention may be utilized;

Fig. 2 is a graph showing the relationship between the secondary electron emission ratio of an approximately 100 to 200-angstrom silicon dioxide film on a tantalum base and an approximately 50 per cent transmission layer of beryllium upon said silica film and the primary voltage, for various heat treatments of the unit;

Fig. 3 is another graph showing the secondary emission-primary voltage ratio for a unit having a 100 to 200-angstrom thick silica film upon a platinum base and an approximately 50 per cent transmission thick beryllium

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layer upon said silica film, for various heat treatment temperatures of the unit;

Fig. 4 is a perspective view of the apparatus for producing films upon a metal base by vapor deposition process; and

Fig. 5 is a perspective view of the crucible included in the apparatus shown in Fig. 4.

Referring now to the drawings, the electron discharge device illustrated in Fig. 1 comprises a highly evacuated hermetically sealed vessel 10 having therein a target 11 and an electron gun comprising an indirectly heated cathode 12 and an accelerating anode 13. The anode 13 is maintained at a positive potential with respect to cathode 12 by a source 14. The electron gun, which can be made by well-known construction methods, projects an electron stream through accelerating anode 13, onto surface 19 of target 11. The target 11 is maintained at a positive potential with respect to the cathode 12 by a source 15, which can be made variable in order to control the amount of electron voltage energy with which an electron strikes the surface 19 of the target 11. Positioned between the accelerating anode 13 and the target 11 is a collector electrode 16, which may be formed in a cylindrical manner as shown. Collector electrode 16 is biased positively with respect to target 11 by source 17 so that it will collect the secondary electron emission from surface 19 of target 11. A load 18 is connected between collector electrode 16 and target 11, the current to load 18 being determined by the amount of secondary electron emission emanating from surface 19 of target 11 and received by the collector electrode 16.

The target electrode 11 comprises a metallic base 11, a layer of silica 20 and a film of beryllium 19. It is to be noted, however, that layer 20 can be any high temperature melting point oxide insulator such as, for example, zirconium oxide, aluminum oxide, manganese oxide, beryllium oxide, and others. It is further to be noted that the metallic base 11 theoretically can be of any metal. However, as a practical matter the melting point of some metals is so low that it would be impossible to apply a film of an insulator material or a film of beryllium on the surface thereof without melting the base 11. Furthermore, for similar reasons not all metals would be suitable as a base 11 since it would be impossible to heat them to a high enough temperature to insure that undesirable impurities had been driven out without melting the metal.

In Fig. 4 there is shown a suitable apparatus for creating a thin layer of silica or beryllium on base 11 utilizing the vapor deposition method. It comprises a vessel 28 evacuated during the process to the order of 10⁻⁵ millimeters of mercury. Within the vessel 28 and upon a base 21 is mounted a pair of brackets 22 upon which the base member of the target is removably held by spring clips 23. The target 11 is exposed to a crucible 24 composed of pure refractory metal, for example of tungsten wire, and shaped in a conical manner as shown. Crucible 24 is supported by leading in conductors 25 extending from terminals 26 secured to the base 21. Contained within the crucible 24 is a predetermined amount of crushed silica (silicon dioxide) indicated in Fig. 5 by reference character 27, the quantity being determined by the desired thickness of the deposited film.

In the process, the crucible is heated by passage of current through the tungsten wire 24. It must be heated to a temperature sufficiently high to vaporize the silica or other material therein but must be low enough to prevent any appreciable vaporization of the tungsten. This is to insure that a pure coating of whatever material is in the crucible is deposited upon target 11. In the case of silica, the time required for evaporation and deposition of a film of the order of 50 to 200 angstroms thick is approximately 15 seconds. This time, of course, must be considered in conjunction with the amount of material 27 placed in the crucible, since the thickness of the film formed upon the target 11 is in part controlled by the amount of material contained in crucible 24. To obtain the above given results, e. g., a thickness of from 50 to 200 angstroms with a heating time of 15 seconds, about 2 milligrams of crushed silica in the crucible 24 are required.

By similar methods, a film of beryllium can be deposited upon the silica layer. To obtain a thickness of beryllium of 50 per cent transmission a small section of glass or other transparent material is placed along the side of target 11. A light is made to pass through the glass and focus upon a photoelectric cell arrangement. As the beryllium deposits upon the target it also deposits upon the adjacent glass and will obstruct the passage of some of the light. When the current generated by the photo-electric cell is decreased to 50 per cent of its original value the beryllium is said to have a 50 per cent transmission thickness.

Alternatively the target may be coated with silicon dioxide, for example, after it has been assembled in the cathode ray device with which it is to be used. Ethyl silicate is pumped into the envelope and then is decomposed by the target, which has been heated, leaving a silicon dioxide film thereon of a controlled thickness which depends on the length of exposure and the temperature of the target.

Upon the completion of the deposition of the two films upon the base metal it is ready for heat treatment. The results of heat treatment at various temperatures are shown in Figs. 2 and 3. Curves A, B and C of Fig. 2 and curves D and G of Fig. 3 are plotted from data obtained by direct current testing while curves E and F of Fig. 3 are plotted from data obtained by pulse testing. As noted hereinbefore, the unit shown in Fig. 1 has a 100- to 200-angstrom thick coating of beryllium on the silica film. Curves A and B are for room temperature while those for curve C were derived with the target heated to a temperature of about 600° C.

In Fig. 2 it is to be noted that the maximum secondary electron emission ratio for all curves therein occurs between 450 and 550 volts. However, the three curves illustrated in Fig. 2 show a marked difference for variations in the heat treatment of the unit. In more particularity it is to be noted that curve A shows the smallest maximum secondary electron emission ratio, representing data taken from the unit before it received any heat treatment whatsoever. Curve B represents data taken from the target electrode unit after it has been heat treated at 750 degrees for three hours. To obtain the data represented for curve C the target was heated to a temperature of 600° C. while being bombarded with a primary electron current. It can be seen that the maximum silica electron emission ratio of curve C is over 12, which is over two and one-half times as much as the maximum of curve A which is about 4.7.

The enhancement of the secondary electron emission ratio due to the heat treatment appears to be a result of a combination of the migration of some of the oxygen of the silica or other metal oxide insulator used into the beryllium coating and a movement of some of the impurities of the tantalum base into the insulating region. The presence of these impurities in the insulating layer break down the insulation somewhat and allow electrons to be pulled through the insulating film to become secondary emission electrons. Some of the impurities present in commercially pure and chemically pure tantalum are:

Tin	Manganese
Palladium	Nickel
Copper	Lead
Gold	Barium
Iron	Silicon

Only a trace of any of these is present, the total impurity content being a fraction of one per cent.

Fig. 3 shows the secondary electron emission ratio versus target voltage for a thin film of beryllium on silica on chemically pure platinum. Curve D, which represents a direct-current primary electron beam test, shows a target unit before it has been heated. The maximum silica electron emission ratio is a little less than 6 with a target voltage of 450 volts. Similar to curve D, curve E was taken before the target unit had been heat treated. However pulse testing was used to obtain data for curve E instead of direct-current testing. The pulses were of 20 microseconds duration with a rate of 1000 cycles per second. It was noted that the maximum secondary electron emission ratio for curve E is less than that for curve D. This is apparently due to the fact that the primary current electrons impinging upon the beryllium surface of the target do not have a great enough time in the case

of pulse testing to build up a sufficiently large charge to draw as many electrons through the insulating layer as occurs when a direct-current primary electron source is applied to the beryllium surface of the target. After the target unit was heated for two hours at 750 degrees the results shown in curve G were obtained wherein the maximum secondary electron emission ratio is greater than 15. This is with a direct-current primary electron source impinging on the target. For a similar heat treatment with a pulsating primary electron current, the results shown in curve F are obtained wherein the maximum secondary electron emission ratio of about 9 is obtained at 700 electron volts energy.

The results obtained after heat treatment of the target unit when the base metal is platinum are due largely to the same reasons set forth above when a tantalum base was discussed. Chemically pure platinum has impurities such as tin, palladium, copper, gold, barium, manganese and silicon which can migrate to the silica insulating layer. Furthermore, some of the oxygen will be released from the silica leaving a certain amount of free silicon atoms which will tend to decrease the insulating effect of the silica.

It is important to note that this process produces a secondary electron surface which will begin to produce secondary emission for all practical purposes instantaneously with the application of a primary electron source to the beryllium surface due to the presence of the tantalum impurities and free silicon atoms within the silica, thus breaking down the insulating properties of the silica to a point where it becomes relatively easy to draw electrons therethrough. The impinging electrons of the primary electron source place an electric charge upon the beryllium which, because of the small dimensions involved, creates an electric field of great intensity in the silica layer to draw electrons therethrough. Furthermore, because of this diminishing of the insulating properties of the silica, the charge upon the surface of the target unit will dissipate itself very rapidly upon the cessation of the primary electron current.

If commercial platinum were used as a base metal instead of chemically pure platinum it would not be necessary to heat it for so long a time since there are more impurities in commercial platinum than there are in chemically pure platinum. Therefore the rate of increase of migration of the impurities from the platinum to the silica would be higher, thus requiring less time to produce the desired results.

It is to be understood that the embodiments of this invention, herein shown and described, are to be taken as preferred examples of the same, and that various changes in materials and proportions may be resorted to, without departing from the scope and spirit of the invention.

What is claimed is:

1. The method of making a secondary electron emitter which comprises applying to a metal base a film of a high temperature melting point oxide insulator, applying a film of beryllium on said oxide film, and heating the composite unit to effect diffusion of the impurities from the base into the oxide.
2. The method of making a secondary electron emitter which comprises the steps of applying to a metal base having a small percentage of impurities therein, a coating of a silicon oxide, applying a film of beryllium upon said silicon oxide, and heating the composite unit at a temperature of approximately 750° C. to effect diffusion of said impurities from said base into said coating of silicon oxide.
3. The method of making a secondary electron emitter which comprises the steps of applying to a tantalum base having a small percentage of impurities therein, a thin layer of silicon dioxide, applying a thin layer of beryllium to said dioxide layer, and heating the composite unit to diffuse said impurities into said silicon dioxide layer.
4. The method of making a secondary electron emitter comprising the steps of applying a 50 to 5000-angstrom thick coating of silicon dioxide on a tantalum base having a fraction of one per cent of impurities therein, applying a 50 to 500-angstrom thick layer of beryllium on said dioxide film, and heating the composite unit at a temperature of approximately 750° C. for approximately 30 minutes.
5. The method of making a secondary electron emitter comprising the steps of applying a 50 to 5000-angstrom

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thick coating of silicon dioxide on a tantalum base having a fraction of one per cent of impurities therein, applying a 50 to 500-angstrom thick layer of beryllium on said dioxide film, and heating the composite unit to diffuse the impurities of the base into said dioxide film.

6. A secondary electron emissive target for electron discharge devices comprising a tantalum base, a thin coating of silicon dioxide thereon having a fraction of a per cent of impurities therein, and a thin coating of beryllium on said silicon dioxide.

7. A secondary electron emissive target for electron discharge devices comprising a metal base, a silicon dioxide layer thereon having a fraction of a per cent of impurities therein, and a thin film of beryllium on said layer of silicon dioxide.

8. A secondary electron emissive target for electron discharge devices comprising a tantalum base, a film of silicon dioxide thereon having a fraction of a per cent of impurities therein and having a thickness of the order of 50 to 5000 angstroms, and a thin film of beryllium on said silicon dioxide film, said beryllium film having a thickness of the order of 50 to 500 angstroms.

9. The method of making a secondary electron emitter which comprises the steps of applying to a platinum base having a small percentage of impurities therein, a thin layer of silicon dioxide, applying a thin layer of beryllium to said dioxide layer, and heating the composite unit to partially diffuse said impurities into said silicon dioxide layer.

10. The method of making a secondary electron emitter comprising the steps of applying a 50 to 5000-angstrom thick coating of silicon dioxide on a platinum base having a fraction of one per cent of impurities therein, applying a 50 to 500-angstrom thick layer of beryllium on said dioxide film, and heating the composite unit at a tempera-

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ture of approximately 750° C. for approximately 30 minutes.

11. The method of making a secondary electron emitter comprising the steps of applying a 50 to 5000-angstrom thick coating of silicon dioxide on a platinum base having a fraction of one per cent of impurities therein, applying a 50 to 500-angstrom thick layer of beryllium on said dioxide film, and heating the composite unit to diffuse said impurities into said dioxide coating.

12. A secondary electron emissive target for electron discharge devices comprising a platinum base, a thin coating of silicon dioxide thereon having a fraction of one per cent of impurities therein, and a thin film of metal on said silicon dioxide coating.

13. A secondary electron emissive target for electron discharge devices comprising a platinum base, a thin film of silicon dioxide thereon, and a thin film of beryllium on said silicon dioxide.

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