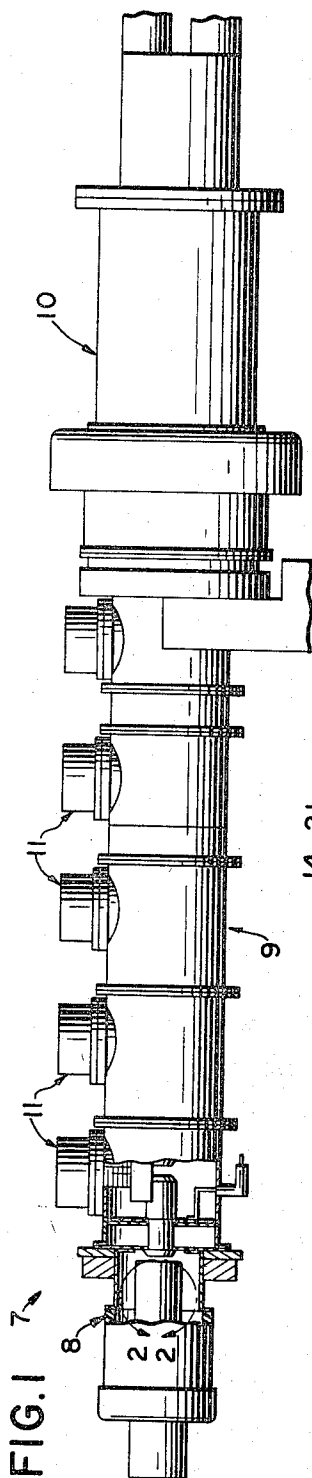
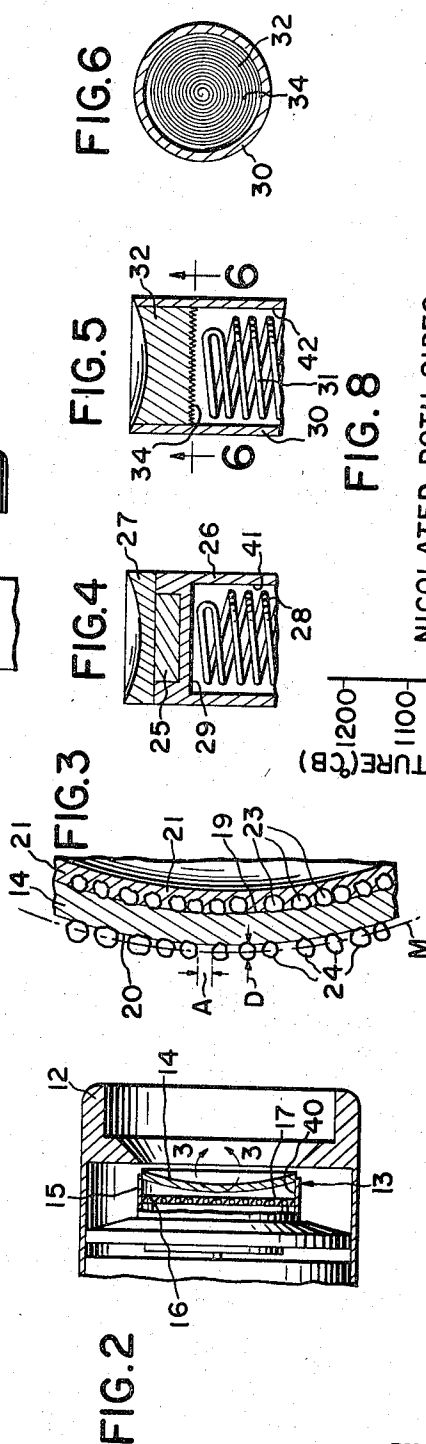
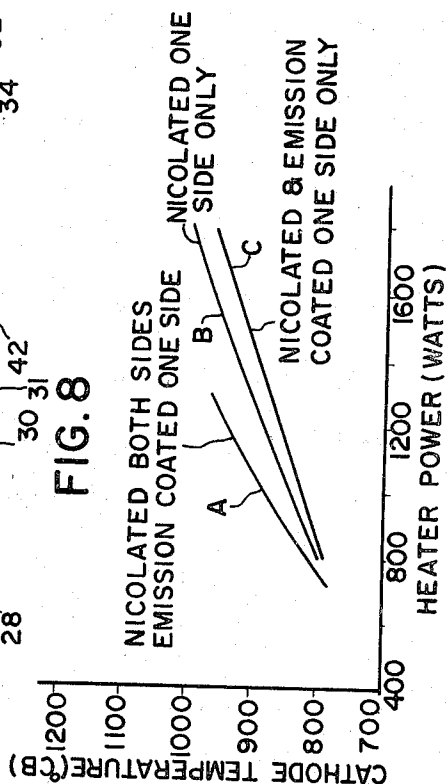
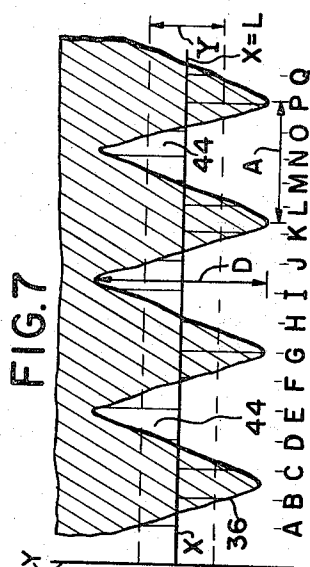


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THERMIONIC CATHODES AND HIGH FREQUENCY
ELECTRON DISCHARGE DEVICES
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3,376,461 THERMIONIC CATHODES AND HIGH FREQUENCY ELECTRON DISCHARGE DEVICES

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ABSTRACT OF THE DISCLOSURE

Improved heat transfer between a thermionic cathode thermal radiation absorption surface e.g., the back portion of a button or base member of an oxide type cathode and a heater element as well as improved radiation from and adherence of electron emissive material to the electron emissive surface of the thermionic cathode with a resultant reduction in heater power requirements for an equivalent emission surface temperature are realized by various roughness techniques such as machining, grinding, deposition of refractory metal particles in a manner such as to approach black body types of radiation and absorption characteristics.

This invention relates in general to high frequency electron discharge devices and more particularly to thermionic (thermal electron emission) cathodes utilizable in such devices and the improvements in such devices through the utilization of thermionic cathodes constructed according to the teachings of the present invention.

Thermionic cathodes play an important role in most high frequency electron discharge devices such as, for example, klystrons, traveling wave tubes, backward wave oscillators, magnetrons, and so forth. Generally speaking, thermionic cathodes of the indirectly heated type are heated through the utilization of filamentary electrodes generally made of tungsten. Serious heat transfer problems are encountered in thermionic cathodes with regard to the efficiency with which heat or thermal energy is radiated from the filament and absorbed by heat absorption surface portions of the cathode.

The present invention is particularly directed toward improving the thermal absorption characteristics of certain portions of a thermionic cathode by roughening the surface of said portions as set forth in more detail hereinafter. The present invention increases cathode life and thus the life of the electron discharge device within which said cathode is utilized by providing a mechanism, for reducing heater temperature and power requirements for a given cathode emission surface temperature without introducing materials which could induce cathode poisoning in use.

Cathode poisoning, which can be defined as any process which inhibits emission, is particularly troublesome in thermionic cathodes and is especially troublesome in oxide and barium dispenser types. Care must be taken to minimize O₂ and CO₂ vapors as well as water vapor in thermionic cathodes since these gases act as emission inhibitors by combining with free barium, per present knowledge. The present invention through the utilization of refractory metals which are free of carbon, for providing a rough thermal radiation absorption surface in thermionic cathodes, overcomes prior art deficiencies which resulted in cathode poisoning. Particular advantages in cathodes whose emission properties are derived from the presence of compounds consisting of alkaline earth oxides and activated by the presence of free alkaline earth metals are achieved by utilizing the teachings of the

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present invention. Test results have indicated that the efficiency of heat transfer between the heater and the thermal radiation absorption surfaces of the cathode which are exposed to the heater are considerably enhanced when utilizing the techniques of the present invention.

In order to set the environment within which the heat transfer improvement techniques of the present invention will particularly apply the following discussion with regard to definitions is in order. The improved heat absorption techniques of the present invention are adapted for, although not limited to, utilization in thermionic cathodes whose emission properties are derived from the presence of compounds consisting of alkaline earth oxides and activated by the presence of free alkaline earth metals. The alkaline earth metals and oxides include barium, strontium and calcium, and their oxides.

Thermionic cathodes having the aforementioned emission properties can be further classified by reference to the following classes:

Oxide cathodes

- (1) Ni button (plain or nickel-platted surface) in conjunction with alkaline earth oxides.
- (2) Ni button in conjunction with Ni wire mesh and alkaline earth oxides.
- (3) Ni button in conjunction with Ni wire mesh and Ni powder mixed with and applied to mesh.

Barium dispenser cathodes

- (1) Internal emission material reservoir
- (2) Impregnated
- (3) Pressed

For a rather comprehensive discussion of the aforementioned types of cathodes, see "Materials and Techniques for Electron Tubes" by Walter H. Kohl, Copyright 1960 by Reinhold Publishing Corporation, New York, N.Y., particularly pp. 519-574.

The aforementioned types of thermionic cathodes are generally provided with a support sleeve made of a refractory metal, e.g., tungsten, molybdenum, rhenium, ruthenium and alloys thereof. The oxide types generally utilize a base or button member made of a refractory metal, e.g., nickel, cobalt, while the barium dispenser cathodes generally utilize as refractory metal base materials, tungsten, or tungsten-molybdenum alloys.

For purposes of definition, the base member is that portion of the thermionic cathode within which the alkaline earth oxides are disposed, upon which the alkaline earth oxides are disposed, or through which the alkaline earth oxides diffuse. According to accepted theory, free barium atoms will continuously form on the emission surface with a resultant reduction in the work function thereof in thermionic cathodes whose emission properties are derived from the aforementioned alkaline earth compounds. Thermal radiation absorption surfaces which are exposed to the heater are the back of the button or base member in the case of a simple oxide coated nickel base cathode, the back of the button and the internal surfaces of the sleeve member within which the heater is disposed and upon which the button or base is supported or, in other words, any portions of the refractory metal surfaces which surround the heater or to which heat is radiated to from the heater element. The present invention teaches providing fine grains, fillings, granules, powders, etc., preferably ranging from (—100 to +325 mesh) in size, of refractory metals, e.g., niobium, tungsten, tantalum, molybdenum, rhenium, cobalt, nickel, ruthenium or alloys thereof on the thermal absorption refractory metal surfaces disposed between the heater and the cathode emission surface and to which the heater is radiating thermal energy while precluding the formation

of gaseous carbon-oxygen compounds during use in order to improve the transfer of radiant heat from the heater to said surface.

The present invention further teaches making a thermal radiation absorption surface to which a thermionic heater is radiating in a thermionic cathode porous in nature such that said porous surface has a surface porosity which is at least greater than 25% and which preferably falls within the range of 25% to 85%.

The present invention further teaches providing a thermal radiation absorption surface to which a thermionic heater is radiating in a thermionic cathode with a surface roughness characterized by having a roughness height rating greater than 125 and preferably about 500 .

The present invention also teaches making a thermal radiation absorption surface to which a thermionic heater is radiating in a thermionic cathode porous such that the average size of the pore, cavity, trough, etc., exposed to the heater has a depth to diameter ratio which is greater than 1 and which is preferably greater than 2.

The present invention further teaches making a thermal radiation absorption surface to which a thermionic heater is radiating in a thermionic cathode of a plurality of refractory metal particles such that said surface is roughened to an extent that a plurality of substantially black body cavities are formed by said particles.

The present invention further teaches making a thermal radiation absorption surface to which a thermionic heater is radiating in a thermionic cathode of a plurality of refractory metal particles, said particles having an average size distribution factor which is not greater than 4 and which particles form a roughened thermal radiation absorption surface which is exposed to said heater.

A direct beneficial result of the teachings of the present invention is a considerable reduction in heater power requirements and a consequent per unit cost reduction, as well as operating cost reduction and increased heater life in electron discharge devices using thermionic cathodes incorporating the teachings of the present invention.

Inherent in the radiant heat transfer improvements resulting from the teachings of the present invention is the absence of any gaseous products which may poison the emitter portion of the thermionic cathode as a result of the utilization of refractory metal granules, filings, powders, etc. or other roughening techniques such as machining or grinding operations to improve the heat transfer characteristics of thermionic cathodes. For purposes of definition, the terminology particles will be used in a generic sense and will include grains, granules, filings, powders, etc.

Therefore, an object of the present invention is to provide thermionic cathodes with improved thermal radiation absorption characteristics.

A feature of the present invention is a thermionic cathode having improved thermal radiation heat transfer characteristics.

Another feature of the present invention is the provision of a thermionic cathode having a thermal radiation absorption surface to which a thermionic heater is radiating, characterized by having a surface roughness height rating greater than 125 and preferably around 500 .

Another feature of the present invention is the provision of a thermionic cathode having a thermal radiation absorption surface to which a thermionic heater is radiating, which surface is porous in nature and has a surface porosity which is at least greater than 25% and which preferably falls within the range of 25% to 85%.

Another feature of the present invention is the provision of a thermionic cathode having a thermal radiation absorption surface to which a thermionic heater is radiating, which surface is porous such that the average pore, cavity, trough, etc. size exposed to the heater has a depth to diameter ratio which is greater than 1 and which is preferably greater than 2.

Another feature of the present invention is the provi-

sion of a thermionic cathode having a thermal radiation absorption surface to which a thermionic heater is radiating, which surface is roughened to an extent that a plurality of substantially black body cavities are formed.

Another feature of the present invention is the provision of a thermionic cathode having a thermal radiation absorption surface to which a thermionic heater is radiating, which surface is made of a plurality of refractory metal particles having an average size distribution factor which is not greater than 4 and which particles form a roughened thermal radiation absorption surface which is exposed to said heater.

Another feature of the present invention is the provision of a thermionic cathode whose emission properties are derived from the presence of compounds consisting of alkaline earth oxides and activated by the presence of free alkaline earth metals having improved thermal radiation heat transfer characteristics.

Another feature of the present invention is the provision of a thermionic cathode having a plurality of fine particles of refractory metals selected from the group consisting of niobium, tungsten, tantalum, molybdenum, rhenium, cobalt, nickel, ruthenium and/or alloys thereof, disposed on thermal absorption refractory metal surfaces exposed to the heater element forming a part of said cathode.

Another feature of the present invention is the incorporation of a thermionic cathode of the type set forth in the aforementioned features in an electron discharge device.

These and other features and advantages of the present invention will become more apparent upon a perusal of the following specification taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a longitudinal view, partly in elevation and partly sectional, of a high frequency electron discharge device of the klystron type incorporating the teachings of the present invention;

FIG. 2 is an enlarged cross-sectional view partly in elevation taken along the area encompassed by the lines 2—2 of FIG. 1 showing the thermionic cathode portion of the tube depicted in FIG. 1;

FIG. 3 is an enlarged cross-sectional view taken along the lines 3—3 of FIG. 2 depicting the oxide-coated base or button portion of the cathode;

FIG. 4 shows a cross-sectional view partly in elevation of a barium dispenser tungsten base cathode having an internal emission material reservoir;

FIG. 5 shows a cross-sectional view partly in elevation of a barium dispenser tungsten base cathode which is representative of both the pressed and impregnated types;

FIG. 6 is a cross-sectional view of the cathode depicted in FIG. 5 taken along the lines 6—6 in the direction of the arrows;

FIG. 7 is an illustrative portrayal of a roughened surface superimposed on a graph for purposes of defining the roughness height rating;

FIG. 8 is an illustrated graphical portrayal of the improvement achieved in thermal absorption characteristics for an oxide-coated cathode constructed according to the teachings of the present invention in comparison with a conventional oxide-coated cathode.

Referring now to FIG. 1, there is depicted therein a high frequency electron discharge device 7 of the multicavity klystron type which includes an electron gun portion 8 disposed at the upstream end thereof, electromagnetic interaction means 9 disposed along the stream length and a collector structure 10 disposed at the downstream end of the device. A plurality of tuner structures 11 are used to control the operating frequency of the device according to known techniques. Since the particular details of the interaction regions and collector regions, tuner cavities and so forth are not critical to the present invention but are merely illustrative, reference to any suitable text may be made for more information con-

cerning these portions. The electron gun portion 8 more clearly shown in FIG. 2 includes a focusing anode 12 made of materials such as, for example, nickel, molybdenum which surrounds the thermionic cathode portion 13 which includes, as shown in more detail in enlarged FIG. 3, a base member or cathode button 14, preferably of nickel, having a concave shape and supported concentrically on a nickel or the like cylindrical supporting sleeve 15. Heater power for the cathode button 14 is supplied as shown in FIG. 2 by preferably tungsten wire. Heater 16 is embedded in an alumina or the like insulation disc 17. Quite obviously, any other suitable insulated or non-insulated form of heater may be used. See FIG. 4, for example.

The oxide cathode button 14 is provided on both the emission side 19 and the absorption side 20 with a plurality of fine particles, 23, 24 preferably nickel filings which, in the case of the emission side, provide a more adherent surface for the emission coating 21 and which, in the case of the absorption side, improve the thermal radiation heat transfer characteristics of the absorption surface by roughening said surface.

In order to better understand the degree of improvement achieved through the application of the nickel particles to the thermal radiation absorption side of the nickel button or base 14 of the oxide-coated cathode depicted in FIGS. 1-3, reference to FIG. 8 is made. FIG. 8 depicts cathode temperature (brightness temperature measured with an optical pyrometer per conventional practice) on the emission side versus heater input power for various types of oxide-coated cathodes. Characteristic A depicts emission surface temperature versus heater power for an oxide cathode such as depicted in FIG. 3 wherein a nickelated (plurality of nickel filings having a particle distribution falling within -100 to +325 mesh) surface is incorporated on both the emission and absorption surfaces of the base or button member. Characteristic B represents an identical button such as 14 of FIG. 3 wherein a similar nickelated surface is applied to the emission surface only without any emission coating on the button. Characteristic C represents a button identical to that shown in FIG. 3 wherein the emission surface is both nickelated and provided with an emission coating and the absorption side of the button 14 is left untreated (not nickelated). A comparison between characteristics A and C shows that better than a 25% reduction in heater power for an equivalent emission surface temperature, such as for example, at 1200 watts input power is achieved when the teachings of the present invention are used. This represents a reduction in heater power supply cost in electron discharge devices using thermionic cathodes of the aforementioned types. Since the heater can operate at a lower temperature for a given emission surface temperature using the teachings of the present invention increased heater life and thus tube life results. Furthermore, no gaseous products or poisoning of the cathode result from the utilization of the improved heat transfer techniques of the present invention. Optimum results have been obtained when using particles having a screen size ranging from (-100 to +325 mesh).

A typical method for applying the nickel filings, granules or powders to the emission and absorption surfaces of a cathode button such as 14 in FIG. 3 is as follows:

(1) Spray nickel oxide on both the emission and absorption surfaces of the nickel button.

(2) Sprinkle nickel particles—preferably filings—screen size, preferably ranging from (-100 to +325 mesh) on the nickel oxide.

(3) Spray another coat of nickel oxide on the filings and another coat of nickel filings and then top it off with another coat of nickel oxide.

(4) Fire the button and coatings for approximately 15 minutes at 1125° C. in dry hydrogen atmosphere.

(5) Press the resultant button in a hydraulic press under approximately one ton per square inch pressure.

(6) Fire the pressed button for approximately 2 hours at 1125° C. in dry hydrogen atmosphere.

Other suitable sintering techniques may be employed to achieve similar results. Similarly, although nickel is preferred in the case of a nickel base oxide cathode, it is to be noted that molybdenum, tungsten, cobalt, tantalum, niobium, rhenium, ruthenium and alloys thereof may similarly be utilized to form the granular thermal absorption coating. The selection, of course, will depend on the refractory metal forming the absorption surface. A pressure of around one ton per square inch has been found to provide excellent adherence of the nickel filings to the nickel base or button. This results from a slight penetration of the filings into the nickel base without exceeding the yield point of the nickel filings which would result in a smoothening of the absorption surface. Sprinkling of the particles on the base and sintering without and pressing operation will produce a rough surface according to the teachings of the present invention but will lack the adherency resulting from the pressing operation.

Other techniques for providing a roughened thermal radiation absorption surface such as grinding and machining operations fall within the broad scope of the present invention and will be discussed in more detail hereinafter.

The enhanced thermal radiation absorption characteristics of the cathode surfaces which are exposed to the heater are achieved by the teachings of the present invention in a manner which leads itself to divergent characterizations which are all conceptually related as discussed in more detail hereinafter.

Considering a given thermal absorption surface area of a thermionic cathode which is exposed to a thermionic heater such as, for example, surfaces 20, 29 and 34 in FIGS. 2-5, the present invention teaches the following concepts with regard to exposed surface porosity.

For a surface depth which can be defined as an average particle diameter in depth the enhanced thermal radiation absorption characteristics of the surface are achieved by the present invention by maintaining an exposed surface porosity which is at least greater than 25% and which preferably falls within the range of 25% to 85%. Porosity is herein defined as

$$\frac{V_p}{V_t} \times 100$$

where V_p = exposed pore volume as measured to a depth which is equal to the average diameter of the refractory metal particles which form the surface and V_t = the total volume measured to the same depth.

The average depth to diameter ratio of the exposed surface pores (apertures) should be greater than 1 and is preferably greater than 2. The aforementioned porosity and depth to diameter ratios will provide a roughened surface which is characterized by having a plurality of minute black body cavities. The actual size of the cavities will, of course, be dependent upon the actual particle size being utilized and the particle size distribution factor. While it is true that an extremely wide variation in particle sizes and range in particle size distribution factors could be used with varying degrees of effectiveness, the present invention finds the following particle sizes and distribution factors to provide optimum results.

Nickel filings having a screen size ranging from -100 to +325 mesh produce excellent results as evidenced by reference to FIG. 8. A particle size distribution factor which is not greater than 4 has produced excellent results with regard to providing the degree of surface roughness necessary to enhance the thermal radiation absorption characteristics of the surface. If distribution factors greater than 4 are employed the danger of filling up surface pores bounded by particles falling in the upper end of the distribution range with particles falling in the lower end of the distribution range increases with the obvious result of loss of exposed pores and reduction in number of

exposed black body cavities. Furthermore, the yield point of the refractory metal particles should not be exceeded during the pressing operation set forth previously. If the yield points of the particles are exceeded reduction in and elimination of exposed pores with a resultant loss in absorptivity can occur.

Reference to FIG. 3 will provide an indication of what parameters are involved with regard to pore depth D and pore diameter A in a greatly enlarged and simplified single layer embodiment which, however, does serve as a basis for illustrating the aforementioned parameters of interest.

The thermionic cathode depicted in FIGS. 2 and 3 is representative of the oxide-coated type of thermionic cathode whose emission properties are derived from the presence of compounds consisting of alkaline earth oxides and activated by the presence of free alkaline earth metals. The alkaline earth metals and oxides include barium, strontium and calcium and their oxides. The terminology oxide-coated thermionic cathode will include the mesh, mesh-mush, mesh-mush and plain or nickelated button surface types which, of course, includes the concave emission surface type such as depicted in FIGS. 2 and 3 as well as the magnetron type. See pages 542 and 543 in particular of the aforementioned Kohl reference.

In FIG. 4, a barium dispenser thermionic cathode having an internal emission material reservoir is depicted wherein a molybdenum sleeve member 26 is used to support a pellet of emission material 25 such as, for example, barium-strontium oxides derived from carbonates or aluminates per conventional practice and a porous tungsten matrix base member 27 is utilized to provide the emission surface to which the free barium atoms migrate during use. A conventional coiled heater 28, such as of tungsten, is used for providing the necessary emission temperatures. The thermal radiation heat transfer characteristics between the heater and emission portions of a barium dispenser tungsten base cathode such as depicted in FIG. 4 are improved according to the teachings of the present invention by depositing, preferably, molybdenum particles on the absorption surface 29 of the molybdenum support sleeve 26 using the previously described techniques. The molybdenum particles will not poison the cathode and inhibit emission by the generation of gaseous reactant products. Molybdenum particles are preferred in a case where the thermal radiation absorption surface is molybdenum as in FIG. 4. In general, the utilization of similar refractory metals for the particles forming the roughened surface and for the surface the particles are deposited upon is desired in order to minimize flaking due to differential thermal expansion which could occur if dissimilar metals were used. In addition, similar metals have a greater affinity for each other than dissimilar metals and will produce a stronger bond during sintering. Since it is desirable to minimize radiation, conduction and convection losses from all portions of a cathode while simultaneously bringing the emission surface up to a given operating temperature with a minimum amount of heater power, it more than likely would not serve any beneficial purpose to roughen the internal sleeve surfaces 40, 41, 42, of the cathodes depicted in FIGS. 2-5 since the cathode designer is really interested only in transferring a maximum amount of heat to the emission surface portion of the cathode with a minimal heat loss. Therefore it would behoove the cathode designer to make all portions of the cathode thermal radiation absorption surfaces, excluding the back portion of the emission surface, namely, surfaces 20, 29 and 34, perfect reflectors so that warm-up time is minimized while simultaneously minimizing the amount of heater power and heater temperature required to maintain thermal equilibrium for a given emission surface temperature.

Where cathode operating temperatures permit and as long as the material melting points of the refractory metals are below the operating temperatures of the heater any

refractory materials such as tungsten, niobium, ruthenium, rhenium, tantalum, molybdenum, nickel and alloys thereof, may be sintered on the thermal radiation absorption surfaces of the cathode to improve the thermal radiation heat transfer characteristics between the heater and the exposed thermal radiation absorption surfaces between the heater and the emission portion of the cathode using conventional sintering techniques.

In FIG. 5, a barium dispenser tungsten base cathode is depicted which is representative of both the pressed and the impregnated types. The barium dispenser cathode depicted in FIG. 5 includes a molybdenum sleeve member 30 surrounding a thermionic heater of tungsten or the like 31 and an emission portion which includes a porous tungsten emitter matrix 32 which incorporates therein, for example, a pressed or impregnated barium-calcium-aluminate for the active material. Once again, the thermal radiation absorption characteristics between the heater and the absorption surface of the cathode which is directly opposite the emission surface is enhanced by roughening the surface 34.

Per conventional practice, in order to eliminate excess barium on the surface the thermal radiation absorption surface 34 in a typical dispenser cathode is machined to a high quality type finish such as, for example, roughness height rating of perhaps $1\frac{1}{2}$. See Mil-STD-10A Oct. 13, 1955 "Surface Roughness, Waviness and Lay," by Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. for a definition of roughness height ratings. The present invention teaches roughening a thermal radiation absorption surface, such as 34 of FIG. 5 and 20, 29 of the embodiments of FIGS. 3 and 4 to an extent that the roughness height rating is greater than $1\frac{1}{2}$ and preferably around 800 . As shown in FIG. 6, the spiraled surface 34 is one example of a roughened surface which is machined by conventional turning or milling operations to a roughness height rating greater than $1\frac{1}{2}$. Any standard grinding and machining operations may advantageously be employed to provide the degree of roughness taught by the present invention.

FIG. 7 shows an illustrative cross-sectional view of a roughened surface 36 superimposed on an X-Y coordinate system for purposes of illustrating how the roughness height rating is arrived at.

By definition, per Mil-STD-10A roughness height rating is a height rating of surface roughness over a length equal to the roughness-width cutoff obtained by averaging the microinch deviations from a mean line.

A mean line is an imaginary line about which roughness height is measured, parallel to the general direction of the profile, so positioned that the sums of the areas contained between it and those parts of the profile which lie on either side of it are equal.

The X coordinate is the mean line in FIG. 7 and the Y coordinate surface deviations A, B, C, D, etc. are used to determine the roughness height rating over a representative length. Therefore,

$$Y = \frac{1}{l} \int_{x=0}^{x=l} |Y| dx$$

Where l = length over which the average is taken (generally at least five to twenty times the roughness width cutoff value depending on the instrument used to measure the value).

Y = ordinate of the curve of the profile, and

Y = average deviations from the mean line (roughness height rating).

For purposes of the present invention the roughness height ratings are for a roughness width cutoff value of .030 inch, and are expressed in microinches. Roughness width cutoff is simply a unit length of the profile over which the irregularities of the surface profile are averaged to obtain the roughness height rating. Generally depending on the size of the cathode, it is desirable to obtain a true representative sampling of the overall surface rough-

ness. Therefore, if say a cathode button of greater than 1" diameter is used and a continuously-averaging type of measuring instrument is used to obtain a value of roughness height rating, a traversing length of not less than twenty times the roughness-width cutoff value is preferably used to determine the roughness height rating. If an instrument is used which provides a reading of integrated roughness over a fixed length of trace, then the traversing length is preferably five times the roughness-width cutoff. The aforementioned techniques for obtaining a representative sample are per Mil-STD-10A recommendations.

The roughness-height rating for particles such as used in the embodiment of FIG. 3 is similarly determined by obtaining the average deviations from the mean line denoted M. There are of course many different degrees of roughness which will provide enhanced thermal radiation absorption characteristics according to the teachings of the present invention.

The terminology "depression" will be used in a generic sense to encompass the pores or cavities formed by the particles utilized in the embodiment of FIGS. 2-4 and the troughs 44 of the machined embodiment of FIGS. 5-7. The surface porosity for the machined embodiment (see FIG. 7) is preferably greater than 25% and should fall within a range of 25% to 85% porosity. Porosity for the machined embodiment is again defined as

$$\frac{V_p}{V_t} \times 100$$

where V_p is the exposed trough 44 volume and V_t is the total volume both measured to a depth equal to the average trough depths D (peak to valley).

Again the ratio of the average trough depth D to the average peak to peak distance A should be greater than 1 and preferably greater than 2 for the machined embodiments.

The thermionic cathodes depicted in FIGS. 2-5 are merely illustrative examples of thermionic cathodes whose emission properties are derived from the presence of compounds consisting of alkaline earth metals. In other words, there are other thermionic cathodes which rely upon the presence of free barium atoms at the emission surface for enhanced emission characteristics and the aforementioned list and examples are not meant to be all inclusive. In any event, the roughening of the thermal radiation heat absorption surfaces as taught hereinabove will provide enhanced thermal radiation absorption heat transfer properties for such thermionic cathodes without poisoning the cathodes.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A thermionic cathode for providing a source of electrons by thermionic emission from an electron emission surface of said cathode whose emission properties are derived from the presence of compounds consisting of alkaline earth oxides and activated by the presence of free alkaline earth metals including a heater element disposed in heat transfer relationship with respect to a base member, said cathode including a thermal radiation absorption surface, said thermal radiation absorption surface forming a unitary structure with said electron emission surface and disposed between said heater element and said electron emission surface such as to receive thermal radiation from said heater in use, said thermal radiation absorption surface being provided with a plurality fine particles of refractory metal having a surface porosity which is at least greater than 25% whereby the thermal radiation heat transfer characteristics between said heater and said surface are enhanced.

2. The cathode defined in claim 1 wherein said cathode is provided with a hollow refractory metal support sleeve surrounding said heater and defining a thermal radiation absorption surface and disposed in thermal radiation heat transfer relationship with respect to said heater.

3. The thermionic cathode defined in claim 1 wherein said cathode is an oxide type and wherein said base is a nickel button, said nickel button defining a pair of surfaces, one of said button surfaces being provided with a coating of active alkaline earth metal oxides, the other of said button surfaces being provided with said plurality of fine particles of a refractory metal.

4. The thermionic cathode defined in claim 1 wherein said plurality of fine particles have a particle screen size falling within the following ranges: (-100 to +325 mesh).

5. The cathode defined in claim 1 wherein said plurality of refractory metal particles are adapted and arranged to define a plurality of substantially black body cavities exposed to said heater.

6. The cathode defined in claim 1 wherein said porous surface is adapted and arranged to provide an average pore size exposed to the heater having a depth-to-diameter ratio which is greater than 1.

7. The cathode defined in claim 1 wherein said plurality of refractory metal particles have an average size distribution factor which is not greater than 4.

8. A thermionic cathode including an electron emission surface and a heater member, said cathode further including a non electron emitting thermal radiation heat transfer absorption surface disposed between said electron emission surface and said heater member, said absorption surface being disposed in thermal radiation heat transfer relationship with respect to said heater, said absorption surface being provided with a plurality of fine particles of material selected from the group consisting of tungsten, nickel, molybdenum, tantalum, rhenium, ruthenium, cobalt, niobium and alloys thereof, said refractory metal particles being adapted and arranged to define a plurality of substantially black body cavities exposed to said heater whereby the thermal radiation heat transfer characteristics between said heater and said absorption surface are enhanced.

9. The thermionic cathode defined in claim 8 wherein said cathode emission properties are derived from the presence of compounds consisting of alkaline earth oxides and activated by the presence of free alkaline earth metals.

10. The thermionic cathode defined in claim 8, including a hollow support member surrounding said heater and defining a thermal radiation heat transfer absorption surface disposed in thermal radiation heat transfer relationship with respect to said heater.

11. The thermionic cathode defined in claim 8 wherein said plurality of fine particles have a particle screen size falling within the following ranges: (-100 to +325 mesh).

12. The cathode defined in claim 8 wherein said absorption surface is characterized by having a surface porosity which is at least greater than 25% as measured to at least a depth equal to the average diameter of the particles forming said surface.

13. The cathode defined in claim 8 wherein said absorption surface is characterized by providing an average pore size exposed to said heater having a depth-to-diameter ratio which is greater than 1.

14. The cathode defined in claim 8 wherein said plurality of refractory metal particles have an average size distribution factor which is not greater than 4.

15. An electron discharge device having improved thermal radiation heat transfer characteristics between a heater member and the electron emitter portion of a thermionic cathode whose emission properties are derived from the presence of compounds consisting of alkaline length oxides and activated by the presence of free alkaline earth metals including a heater element disposed

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in heat transfer relationship with respect to a base member, said cathode including a non electron emitting thermal radiation absorption surface, said absorption surface being disposed in said thermionic cathode such as to receive thermal radiation from said heater in use, said absorption surface being provided with a plurality of fine particles of refractory metal having a surface porosity exposed to said heater which is at least greater than 25% whereby the thermal radiation heat transfer characteristics between said heater and said absorption surface are enhanced.

16. An electron discharge device having improved thermal radiation heat transfer characteristics between a heater member and a thermionic cathode including an electron emission surface and a heater member, said cathode further including a non electron emitting thermal radiation heat transfer absorption surface disposed between said electron emission surface and said heater member, said absorption surface being disposed in thermal radiation heat transfer relationship with respect to said heater, said absorption surface being provided with a plurality of fine particles of material selected from the group consisting of tungsten, nickel, molybdenum, tantalum, rhenium, ruthenium, cobalt, niobium, and alloys thereof, said particles having a surface porosity at least greater than 25% whereby the thermal radiation heat transfer characteristics between said heater and said absorption surface are enhanced.

17. A thermionic cathode activated by the presence of free alkaline earth metals having a heater member disposed in thermal radiation heat transfer relationship with respect to a non electron emitting thermal radiation absorption surface forming a part of said cathode, said absorption surface being provided with a plurality of fine particles of a refractory material selected from the group consisting of tungsten, nickel, molybdenum, tantalum, rhenium, ruthenium, cobalt, niobium and alloys thereof, said particles defining a surface exposed to said heater which is characterized by having a surface porosity greater than 25% whereby the thermal radiation heat transfer absorption characteristics of said surface are enhanced.

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18. The thermionic cathode defined in claim 17 wherein said plurality of fine particles have a particle screen size falling within the following ranges: (-100 to +325 mesh).

19. The thermionic cathode defined in claim 17 wherein said cathode is an oxide type having a nickel base supported by a hollow refractory metal sleeve within which said heater is disposed, said nickel base defining a pair of surfaces, one of said base defining a pair of surfaces, one of said base surfaces being provided with a coating of active alkaline earth metal oxides, the other of said base surfaces being disposed in thermal radiation heat transfer relationship with respect to said heater and being provided with a plurality of fine particles of a refractory metal, said fine particles being nickel particles sintered on said base surface and having a particle size falling within the following ranges: (-100 to +325 mesh).

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