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[54] FIELD EMISSION ELECTRON GUN WITH ANODE HEATER AND PLURAL EXHAUSTS

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[30] **Foreign Application Priority Data**

Feb. 8, 1978 [JP] Japan .... 53-13722[U]

[51] **Int. Cl.**[3] **H01J 7/16**

[52] **U.S. Cl.** **313/7**; 313/180; 250/457

[58] **Field of Search** 313/7, 180, 38, 452; 250/457

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[57] **ABSTRACT**

In a field emission electron gun including heating means for heating an anode to prevent gas emission from the anode due to bombardment thereof by the electron beam emitted from the cathode, the present invention provides a field emission electron gun including first exhaust means for defining a first chamber including the cathode and for exhausting said chamber to vacuum, and second exhaust means separate from said first exhaust means defining a chamber including said anode heating means for exhausting said chamber to vacuum independently of the first exhaust means. This construction makes it possible to maintain the chamber including the cathode constantly in the high vacuum state.

7 Claims, 2 Drawing Figures

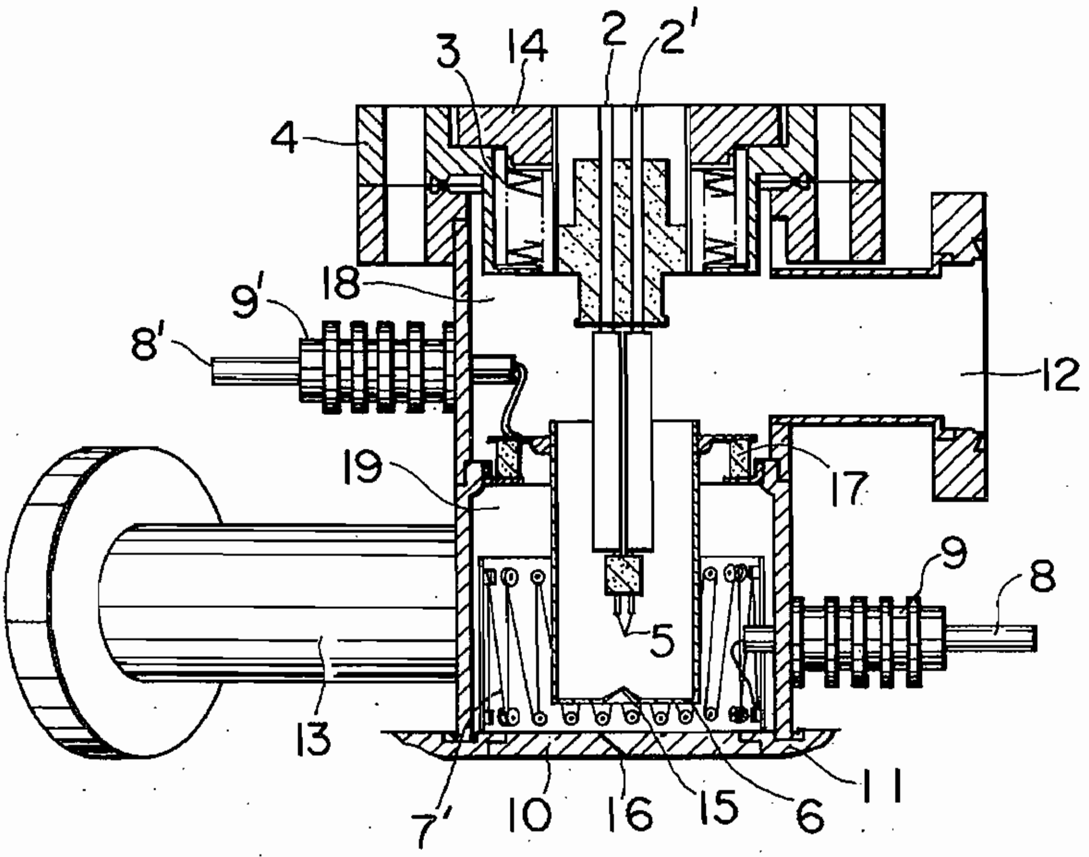


FIG. 1

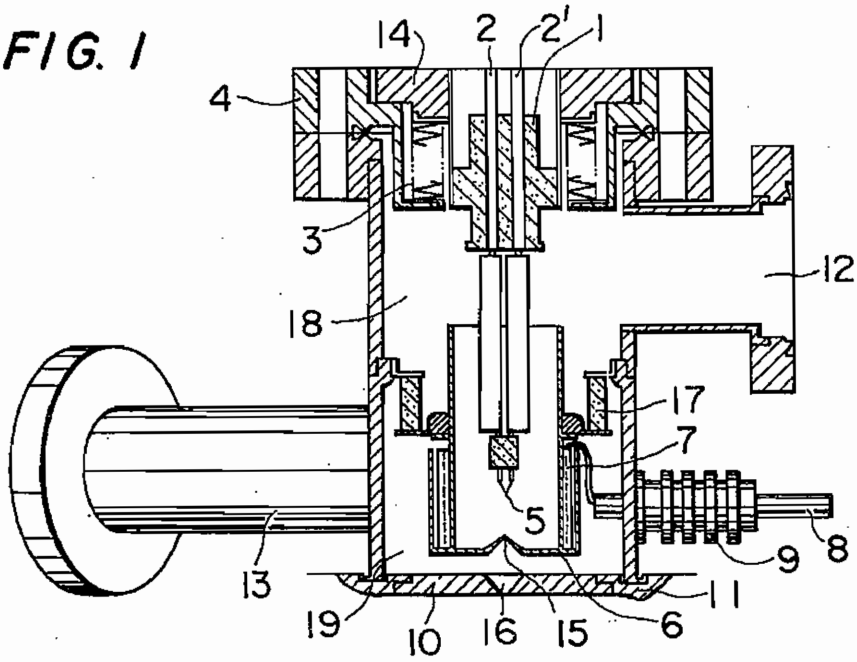
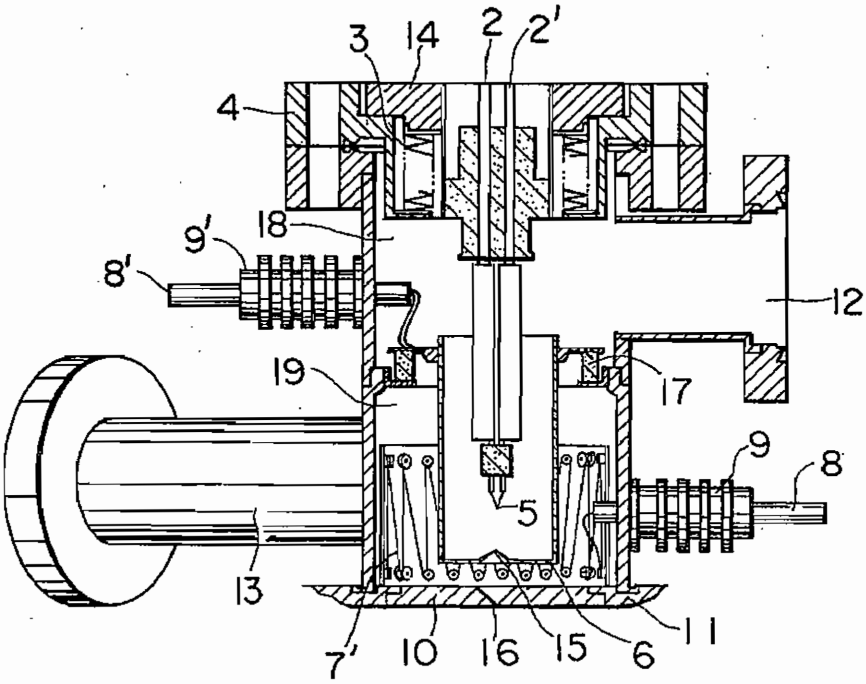

14
2
2'
1
4
3
12
18
17
7
5
8
9
13
11
19
10
16
15
6

FIG. 2


3
14
2
2'
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9'
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9
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6

FIELD EMISSION ELECTRON GUN WITH ANODE HEATER AND PLURAL EXHAUSTS

BACKGROUND OF THE INVENTION

This invention relates to an improvement in a field emission electron gun to be used for a scanning type electron microscope and the like.

The field emission electron gun has the excellent feature that in comparison with a thermal electron gun, it has a brightness 10^3 times as high as that of the latter. To put the field emission electron gun to practical use, however, it is necessary to place the gun under a high vacuum of below 10^{-9} Torr. To maintain this high vacuum during emission of electrons, furthermore, it is an essential requirement to prevent gases emitted from the anode due to electron bombardment from contaminating the atmosphere of the electron gun in the vicinity of the cathode.

As a method of preventing such gas emission, there has conventionally been known a heating degassing method in which the anode is heated by heating means, such as a heater, so as to perform degassing. According to this method, however, large quantities of gases are emitted from the heating means itself during the treatment of the anode, thereby lowering the vacuum and thus failing to maintain the high vacuum state.

SUMMARY OF THE INVENTION

The present invention provides a solution to the above-mentioned problem and is directed to provision of a field emission electron gun which is capable of maintaining constantly the high vacuum state in the vicinity of the cathode.

To accomplish the above-mentioned object, the apparatus of the present invention includes a field emission cathode, an anode, heating means for heating the anode and thereby preventing the gas emission from the anode caused by bombardment of electrons emitted from the cathode, a first exhaust means defining a chamber including the cathode for exhausting the chamber to vacuum and a second exhaust means disposed adjacent the first exhaust means via the anode, defining a chamber including the anode heating means for exhausting the chamber to vacuum independently of the first exhaust means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing an embodiment of the field emission electron gun in accordance with the present invention; and

FIG. 2 is a schematic view showing another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows an exemplary embodiment of an electron gun in accordance with the present invention in which a field emission cathode **5** (or FE-tip) is secured to lead terminals **2,2'** passing through a vacuum-resistant insulator **1**, which is connected to a sliding flange **14** and also to a flange **4** via a bellows **3**. The sliding flange **14** is allowed to move horizontally by means of an adjust screw (not shown) so as to make it possible to center the field emission cathode with respect to an aperture **15** of a first anode **6**.

In this embodiment, the first anode **6** has a cup-like shape with the aperture **15** through which an electron beam is allowed to pass being located at its bottom. The aperture **15** may have a diameter ranging from about 0.2 to about 1 mmϕ and has generally a diameter of about 0.5 mmϕ. The first anode **6** is secured to one side of a ring-like insulator **17**, the other side of which is secured to the wall **20** of the electron gun in any conventional manner. Heating means **7**, such as a heater, is externally wound around the first anode **6** so that the anode is heated when current is fed from a pin **8** of a lead insulator **9** to the heating means **7**. The first anode **6** is secured to the ring-like insulator **17** so as to be thermally insulated. It is therefore possible to easily heat the first anode **6** to a high temperature. For the degassing treatment, a temperature of about 300°-500° C. is necessary.

A second anode **10** having an aperture **16** in alignment with the aperture **15** is disposed below the first anode **6**. The electron beam passing through the apertures **15** and **16** from the cathode **5** is either condensed or magnified by an electron lens which is formed at the lower portion of the flange **11**.

The electron gun is divided into two chambers, i.e., an upper chamber **18** and a lower chamber **19**, that are exhausted, respectively, by exhaust ports **12** and **13**. Vacuum communication between the chambers **18** and **19** is established only through the aperture **15** through which the electron beam passes. Therefore, it is possible to maintain a vacuum difference between the upper chamber **18** and the lower chamber **19** in order of two digits at this aperture **15**. The table below illustrates an example of the relationship of vacuum between the upper chamber and the lower chamber, using the diameter d of the aperture as a parameter.

Vacuum of Upper Chamber			Vacuum of
d = 1mm	d = 0.5mm	d = 0.2mm	Lower Chamber
Torr	Torr	Torr	Torr
9×10^{-8}	2.3×10^{-8}	3.6×10^{-9}	1×10^{-6}
9×10^{-9}	2.3×10^{-9}	3.6×10^{-10}	1×10^{-7}
9×10^{-10}	2.3×10^{-10}	3.6×10^{-11}	1×10^{-8}

As can be seen from this example, when d=0.5 mm and the vacuum in the upper chamber is 2.3×10^{-8} Torr, whereby it is possible to maintain a vacuum difference between the two chambers in order of two digits. Incidentally, this example represents a case where both the upper chamber **18** and the lower chamber **19** are exhausted respectively by the use of two vacuum pumps (e.g., ion pumps, etc.) each having substantially an equal capacity to the other. If a vacuum pump having a greater capacity is used for exhausting the upper chamber, the vacuum difference between the two chambers can be further enhanced.

FIG. 2 shows another embodiment of the present invention wherein reference numerals **1** through **19** are used to identify like constituent elements as appear in the embodiment of FIG. **1**. In this embodiment the heating means **7'**, such as a heater, is disposed outside the first anode **6** so as to heat the anode **6** by radiant heat. In this case also, the objects of the present invention can be achieved in a manner similar to that previously described. Namely, a vacuum difference can be maintained between the upper chamber **18** and the lower chamber **19** in the same way as in the first embodiment. In FIG. **2** the first anode **6** is supplied with a voltage via the pin **8'** of the lead terminal **9'** and the heating means **7'** is fed with a current and heated from the pin **8** of the lead terminal **9**.

As explained above, the present invention has the construction wherein the first anode **6** is used as the vacuum separation wall. Accordingly, it is possible to prevent lowering of the vacuum in the chamber housing the cathode **5** due to gases emitted in large quantities from the heating means associated with the first anode during treatment of the anode. Even when the vacuum becomes 10^{-6} Torr in the lower chamber, for example, it is possible to maintain the vacuum of 10^{-8} Torr in the upper chamber. The lead terminal **9** is prepared to withstand high voltage and the electron gun of the present invention is used as an ordinary butler type electron gun after heat treatment of the first anode **6**.

It is to be noted that the present invention is not necessarily limited to the use of a first anode of particular shape, to heating means of particular form and the like or to the definite numeric values used for the explanation of the above-mentioned embodiments, and that these features can be suitably selected or adapted in accordance with set conditions.

While we have shown and described an embodiment of the present invention, it is to be understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those of ordinary skill in the art, and we therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are obvious to those skilled in the art.

What is claimed is:

1. A field emission electron gun comprising:

a field emission cathode;

an anode having an aperture through which an electron beam emitted by said cathode can pass;

heating means for heating said anode;

a first chamber in which said cathode is disposed;

first exhaust means for evacuating said first chamber;

a second chamber adjoining said first chamber through said anode and in which said heating means is disposed, and

second exhaust means for evacuating said second chamber independently from said first chamber.

2. The field emission electron gun as defined in claim 1 wherein said anode has a cup-like shape having at its bottom said aperture allowing passage therethrough of the electron beam emitted from said cathode.

3. The field emission electron gun as defined in claim 1 wherein said heating means is disposed around the outer circumference of said anode.

4. The field emission electron gun as defined in claim 1 wherein said heating means consists of a heater in contact with said anode.

5. The field emission electron gun as defined in claim 1 wherein said heating means consists of a heater spaced from said anode.

6. The field emission electron gun as defined in claims 1 or 2 wherein the diameter of said aperture formed in said anode is in the range of from 0.2 mm to 1.0 mm.

7. The field emission electron gun as defined in claims 1 or 2 wherein the diameter of said aperture formed in said anode is 0.5 mm.

* * * * *

⑲日本国特許庁（ＪＰ）　⑪特許出願公告

⑫特許公報（Ｂ２）　平3－15297

⑤Int. Cl.⁵　識別記号　庁内整理番号　㉔㊹公告　平成3年(1991) 2月28日

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3/02　8320－5C
19/70　7525－5C

発明の数　1　（全3頁）

⑤発明の名称　電界放射電子銃

審判　昭58－23313　㉑特願　昭54－3958　㊸公開　昭55－1062
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前実用新案出願日援用

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⑯参考文献　特開　昭48－52170（ＪＰ，Ａ）　特開　昭52－57772（ＪＰ，Ａ）
特開　昭48－17965（ＪＰ，Ａ）　特開　昭48－20473（ＪＰ，Ａ）

⑰特許請求の範囲

1　電界放射陰極と、該陰極に対面して配設されたカツプ形状の陽極と、前記陽極のなすカツプ形状の外周側面にあつて前記陽極を加熱し得る陽極加熱手段とを具備し、かつ前記陰極を含むチヤンバーと、該チヤンバーとは前記陽極を介して隣る前記陽極加熱手段を含むチヤンバーとを、それぞれ独立させ、各チヤンバーに独立の真空排気手段を設けたことを特徴とする電界放射電子銃。

発明の詳細な説明

本発明は、電界放射電子銃の改良に関するものである。

電界放射電子銃は熱電子型電子銃に比較して、輝度が10^3倍もあるという優れた特徴をもつている。しかしながら、その実用化には、10^{-9}トール以下の高真空下におく必要がある。この高真空を電子放射中に維持するためには電子衝撃により陽極から放出されるガスを防ぐことが必須の条件となる。

従来、上述のガス放出を防ぐ一手段として、ヒーター等の加熱手段によつて陽極を加熱して、脱ガスを行なう昇温脱ガス法がある。しかしながら、これによると陽極処理中にヒーター等の加熱手段自体から大量にガスが放出され、これによる真空低下を生起することになり、上述した高真空状態を保つことができなくなる。

本発明は、かゝる点に着目してなされたものであり、ガス放出用加熱手段からのガス放出をなくし、つねに高真空状態を保つことのできる電界放射電子銃を提供するものである。

本発明を図により、詳細に説明する。電界放射陰極6は耐真空の碍子1の導入端子2，2′に固定されている。碍子1は摺動フランジ15に接続され、ベローズ3を介してフランジ4に接続している。摺動フランジ15は調整ネジ5により水平移動する。この機構により、電界放射陰極6が第1陽極7の開口16にセンタリングされる。この例では、第1陽極7はカツプ形状からなり、その底に電子線が通過し得る開口を有する。開口16は口径0.2㎜～1㎜φ程度あればよいが通常0.5㎜φ程度である。第1陽極7はリング状碍子18に固定されている。また第1陽極7の外側にはヒーター等の加熱手段8が巻きつけられ、導入碍子10のピン9から通電により、加熱される。第1陽

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極７はリング状碍子１８で固定され、熱絶縁されている。このため第１陽極７は容易に高温にすることができる。脱ガス処理には、300℃～500℃が必要である。第１陽極７の下方には、開口１７をもった第２陽極１１が設けられている。開口１６，１７を通つた電子線はフランジ１２の下方に接続される電子レンズにより集束、あるいは拡大される。この電子銃は排気口１３と排気口１４で排気される２つのチヤンバー、すなわち上室１９と下室２０に分離されている。真空的な接続は両チヤンバーの電子線の通る開口のみである。この開口１６では、上室１９と下室２０との真空差を２桁に保つことが可能である。

下表は一例としてこの上室１９と下室２０の真空度の関係を、開口１６の口径(d)をパラメータとして示したものである。

例

上室の真空度			下室の真空度
d＝1mm	d＝0.5mm	d＝0.2mm	
9×10^{-8}Torr	2.3×10^{-8}Torr	3.6×10^{-9}Torr	1×10^{-6}Torr
9×10^{-9}	2.3×10^{-9}	3.6×10^{-10}	1×10^{-7}
9×10^{-10}	2.3×10^{-10}	3.6×10^{-11}	1×10^{-8}

この例から、前述したように上室と下室との真空差を２桁に保つことが可能であることがわかる。なお、本例は、上室１９と下室２０とをそれぞれほゞ同程度の真空排気容量を持つ真空ポンプ（例えば、イオンポンプ等）によつて真空排気した場合について示したものであるが、上室１９をさらに強力な真空ポンプを用いて真空排気すれば、上室と下室の真空差をさらに大にすることが可能である。また、第１陽極７をカツプ形状にしているのは、第１陽極７で散乱した電子が昇温脱ガス処理をしていない上室１９の内壁を衝撃しそれによる真空低下を防ぐためであり、前記散乱した電子をカツプ形状内にとじこめるようにしたものである。

以上のように、本発明によれば、第１陽極を真空の分離壁とした構成により、陽極処理中にヒーター等の陽極加熱手段から大量に放出するガスによる真空低下を防ぐことができる。例えば、下室の真空度が10^{-6}トール（Torr）になつても、上室は10^{-8}トールに保つことが可能である。導入碍子１０は高電圧に耐えるように作られ第１陽極７の加熱処理後は、通常のバトラー型電子銃となる。

本願発明のようにカツプ形状の陽極の外周に陽極加熱手段を設けることにより、陽極加熱手段は陰極を含むチヤンバーの外部にありながら、すなわち陰極を含むチヤンバーが陽極加熱手段からの放出ガスによつて真空低下を生起させない状態で、陽極を加熱して脱ガスを行なうことが可能となり、陽極の処理を完全なものとすることができる。この結果、電子放射中に陽極から生じるガス放出が著しく減少し、高真空状態を保つて安定な電子放射が可能となる。また、陽極を衝撃した放射電子のうち約半数の電子はその周囲に散乱するが、陽極をカツプ形状とすることによつて、散乱した電子は高温脱ガス処理をした陽極内に閉じ込めることが可能で、脱ガス処理された陽極以外の外部部材を衝撃する散乱電子を著しく減少させ、陽極処理に効果を向上させることができるものである。

図面の簡単な説明

図は、本発明の一実施例を示す図である。図において、

６……電界放射陰極、７……第１陰極、８……ヒーター、９……ピン、１０……導入碍子、１１……第２陽極、１３，１４……排気口、１６，１７……開口、１９……上室、２０……下室。

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