Dec. 13, 1966 SHINJIRO KATAGIRI ETAL 3,292,041

MULTISTAGE TYPE HIGH VOLTAGE ELECTRON GUN
WITH CONTROLLABLE ELECTRODE SPACING

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FIG. 1

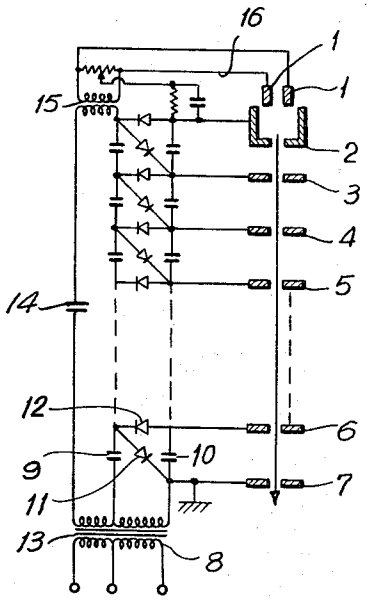

FIG. 3

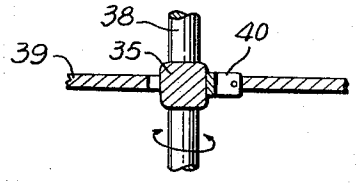

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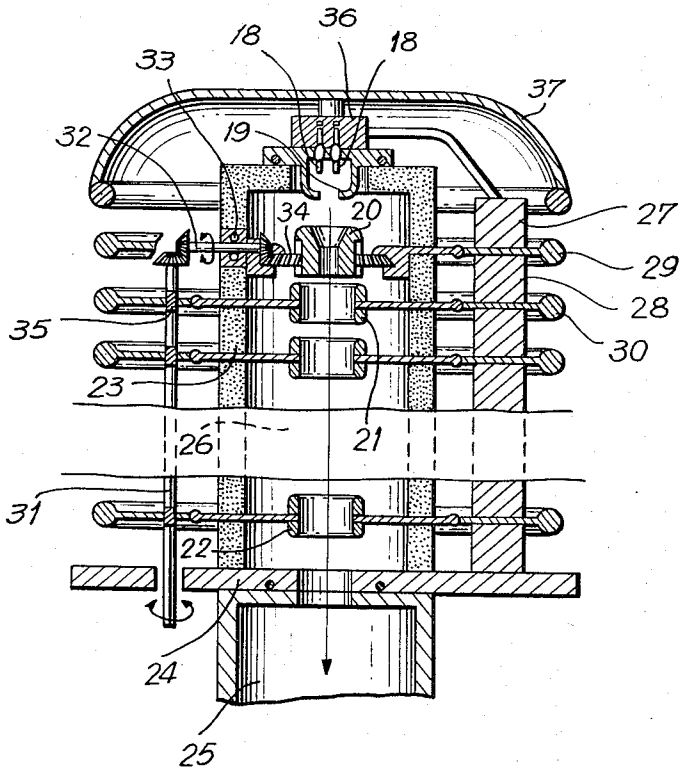
FIG. 2



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3,292,041

MULTISTAGE TYPE HIGH VOLTAGE ELECTRON GUN WITH CONTROLLABLE ELECTRODE SPACING

Shinjiro Katagiri, Kodaira-shi, Tokyo, and Hirokazu Kimura, Kogane-shi, Tokyo, Japan, assignors to Hitachi, Ltd., Tokyo, Japan, a corporation of Japan

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1 Claim. (Cl. 315—357)

This invention relates to a multi-stage-type high-voltage electron gun.

As is well known, due to the increase of accelerating voltages of electron guns in electron microscopes, electron diffraction apparatus and the like, it has become difficult to operate those apparatuses stably without adopting multistage accelerating system.

For this reason, when a power supply of a Cockcroft-Walton accelerator system is used, the number of voltage step-up stages and the number of accelerating electrodes are usually equalized to facilitate electrical connection and, when a power supply of a Van de Graaff system is used, a proper resistance divider is usually used to divide the voltage.

Further, in the said electron microscope and the like, since the optimum accelerating voltage must be differentiated depending upon the thickness of the specimens, it is desirable that the accelerating voltage can be changed over a wide range. Assuming the maximum accelerating voltage to be 500 kv. and the number of accelerating stages to be ten, the maximum potential difference between each stage is 50 kv. Assuming the minimum accelerating voltage to be 50 kv., the minimum potential difference is only 5 kv. However, in case the structure of a multistage electron gun is designed with the maximum accelerating voltage, the electron beam intensity becomes too low at the minimum accelerating voltage as the accelerating voltage at the first stage is then too low. Therefore, in the structure of the conventional multistage electron gun, the maximum and the minimum accelerating voltage ratio in the range of practical use is only about 3:1.

It is an object of this invention to overcome the defects of said conventional multistage electron gun.

It is still another object of this invention to provide for changing an accelerating voltage over a wide range without large variations of brightness and focussing of electron beam.

It is still a further object of this invention to expand the range of practical use to a degree of 10:1 in voltage ratio.

In order to accomplish said objects according to this invention, there is provided a new and improved multistage type high voltage electron gun which comprises a cathode for emitting an electron beam, a number of anodes for accelerating said electron beam and means for varying the distance between said cathode and the first accelerating anode in accordance with the accelerating voltage applied to said anodes.

Other objects and advantages of the invention will become apparent by reference to the following detained description in conjunction with the accompanying illustrations, in which:

FIG. 1 is a circuit diagram showing the principle of this invention; and

FIG. 2 and FIG. 3 are sectional views showing the structure embodying this invention.

While the invention will be described in connection with a preferred embodiment, it will be understood that the invention is not limited to the embodiment shown

but, on the contrary, covers the various alternatives and equivalent constructions included within the spirit and scope of the appended claim.

In the drawing, FIG. 1 is a schematic diagram explaining the principle of the multistage high voltage electron gun of the present invention. FIG. 1, 1*a* denotes cathode filament adopted for electron emission, **2** denotes a Wehnelt cylinder for electron beam control, and elements **3**, **4**, **5**, **6**, **7** and so on denote accelerating anodes. The anode **7** of the final stage is grounded. Accelerating high voltage is supplied with a step-up transformer **8** by means of which acceleration can be adjusted and each accelerating stage is connected in series with condensers **9**, **10** and rectifiers **11**, **12** and is constructed according to the so-called Cockcroft-Walton system. Each stage is connected with an accelerating anode. Further, the filament current is supplied with a coupling coil **15** through a coupling circuit consisting of a coupling transformer **13**, condensers **14**, **9** and the like, and the filament circuit is connected to the high voltage circuit through a self-bias circuit.

In the said example, assuming that the maximum accelerating voltage is 500 kv. and the minimum accelerating voltage is 50 kv., the accelerating voltage in each stage varies from 50 kv. to 5 kv. Then, the accelerating electric fields, except the accelerating electric field of the first stage, have relatively little effect upon the focussing of the electron beam even if the accelerating voltage is changed. The electric field in the first stage has, however, a remarkable effect upon the emission and focussing of electrons. Therefore, for example, when an accelerating voltage is changed according to the said ratio 10:1, it is important to keep constant the field intensity of the first stage produced by electrodes **1**, **2**, **3** in FIG. 1. In the present invention, as the structure of the first accelerating stage is so designed as will be described later, it is accordingly an object of the present invention to expand the range of the accelerating ratio by keeping the electric field of the first stage always constant.

In FIG. 2 which shows the structure of an embodiment of the invention, **18** denotes a cathode filament, **19** denotes a Wehnelt cylinder, **20** denotes the first anode, **21**, **22** and so on denote multistage anodes in envelope **23**. The anode **24** of the last stage is grounded and the said structure follows an electron lens system **25** through a vacuum packing. Each of the above anodes is insulated by insulators made of porcelain or glass and the like and is sealed in vacuum at the same time. The interior of electron gun **26** is isolated from the exterior atmosphere or high-pressure insulating gas and the like. Each stage contains an electric power supply **27**, **28** which consists of condensers, rectifiers and the like, and each stage is provided with its respective accelerating voltage. Further, each stage has external corona shields **29**, **30**, etc.

The first anode **20** is moved vertically by rotating a gear **34** through a vacuum seal **33** and insulated driving rods **31**, **32** at the grounded side. Thereby the gap between the first anode **20** and the cathode consisting of filament **18** and Wehnelt cylinder **19** can be changed freely. Even in case an accelerating voltage is changed over a wide range, as the intensity of electrical field therebetween can be always kept constant by adjusting the said first anode **20** properly, the apparatus of the said embodiment may be used without substantially changing brightness and focussing of the electron beam. In this case, the insulated driving rod **31'** may be used stably by providing an electrically conductive part **35** in the region where rod **31** passes through each accelerating stage and giving part **35** the same potential as the potential of each stage. Element **36** is a filament power supply and element **37** is a corona shield.

In FIG. 3 which shows the said driving rod **31** in de-

tail, electrically conductive part **35** is provided in a part of the insulated part **38** and is always kept at a constant potential even in operation by a slip ring **40** mounted on a shield plate **39** whose potential is equal to that of each stage, whereby it is devised that a uniform potential distribution may be kept over its whole length.

As stated above, the prinicpal object of the invention is accomplished by changing the gap between the first stage anode and the cathode in accordance with changes of accelerating voltage in a multistage accelerating electron gun. In the said embodiment, though explanation is made of a case in which the first anode is movable, it is easily understood that the cathode may be made movable by keeping the first stage anode in fixed attitude and the distance between the cathode and the first stage anode may be adjusted by keeping the cathode and the other anodes joined in a body. Further, an insulating rod is used for driving the first anode but other means may also be used. For example, the first anode may be drived through a high frequency signal supplied from the grounded side by utilizing a high frequency servomotor.

Anyhow, when an electron accelerating voltage is changed by changing the voltage supplied to the step-up transformer **8** in FIG. 1, the intended object will be accomplished by maintaining a substantially constant field intensity by changing the distance between the cathode and the first stage anode in accordance with the change of applied voltage.

Having now described the invention, what is claimed as new and novel and for which it is desired to secure by Letters Patent is:

A multistage electron gun comprising electron emission means, a first anode, a plurality of further anodes aligned with each other and with said first anode, support means holding said further anodes in fixed relationship with each other, means for applying successively larger voltages respectively to said first and further anodes whereby the anodes provide acceleration stages for electrons from said emission means, means to vary said voltage and thereby said acceleration, and control means to vary the relative spacing between the electron emission means and said first anode to compensate for variations in said voltage, said emission means being fixed relative to said further anodes, said control means being adapted to move said first anode, said support means being a vacuum-tight envelope, said control means including a gear means extending through said envelope and engaging said first anode, and an insulating rod extending along said further anodes outside of said envelope and engaging and operating said gear means, said rod including conductive elements electrically connected to said further anodes.

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JAMES W. LAWRENCE, *Primary Examiner.*

R. SEGAL, *Assistant Examiner.*