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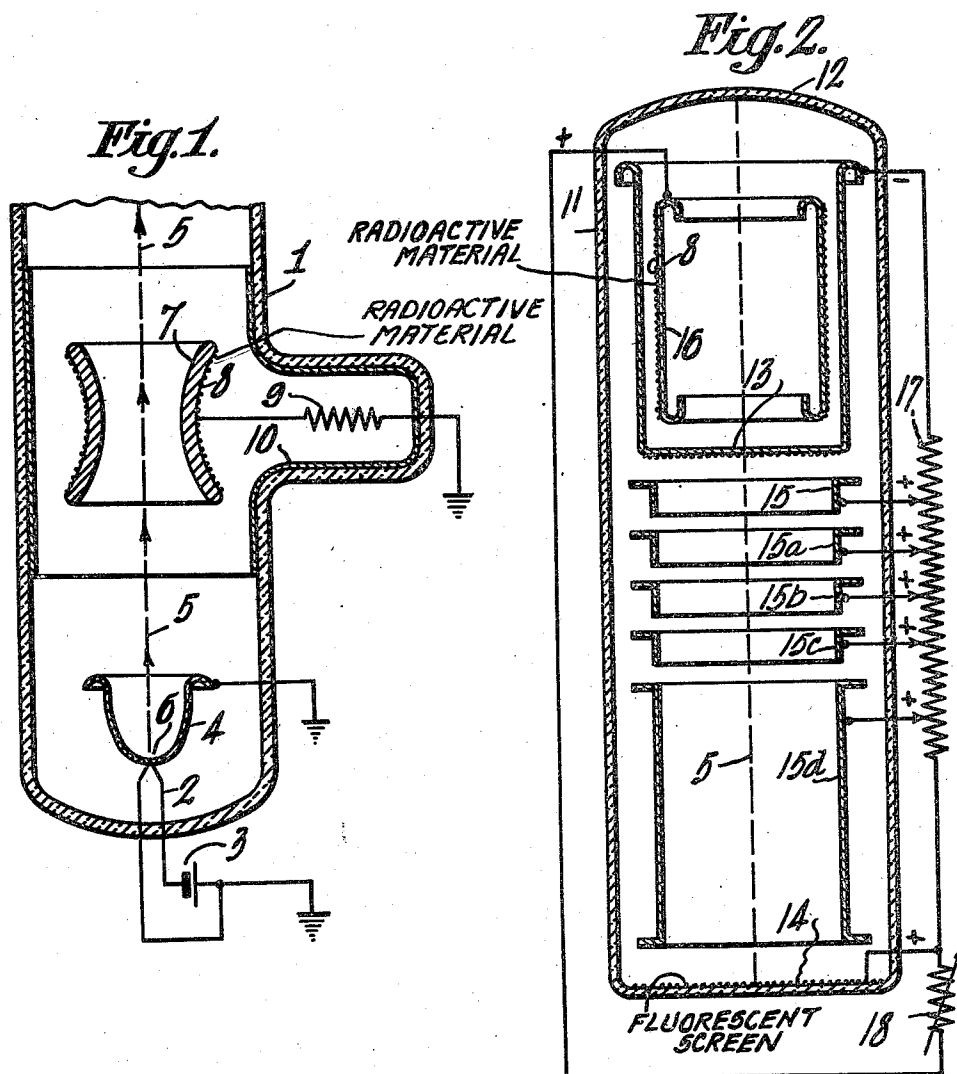
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RADIOACTIVE MONOKINETIC CHARGED PARTICLE GENERATORS

Filed June 1, 1950

2 Sheets-Sheet 1



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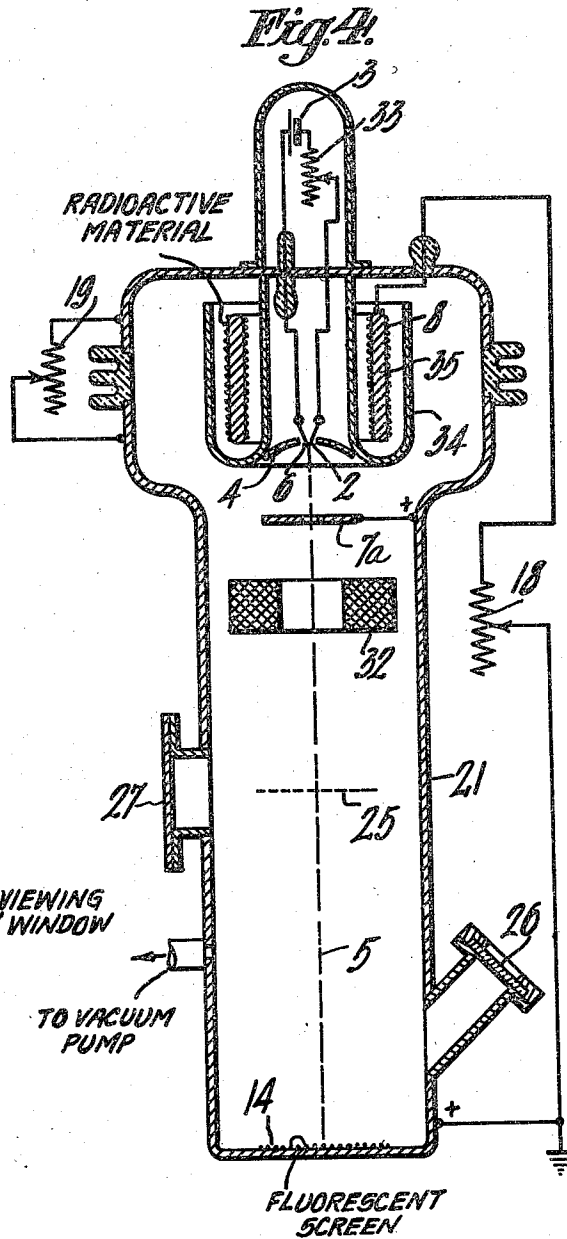
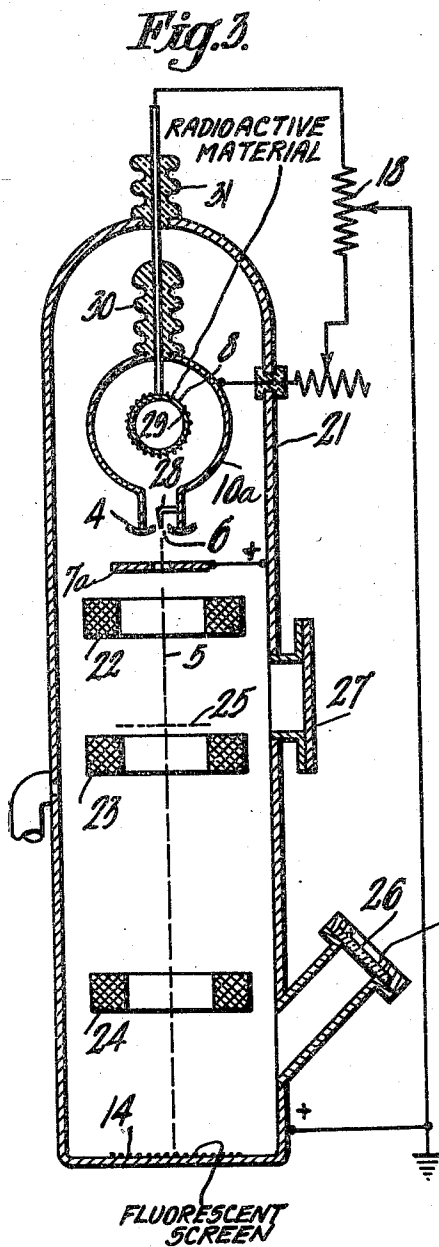
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RADIOACTIVE MONOKINETIC CHARGED PARTICLE GENERATORS

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Application June 1, 1950, Serial No. 165,447

12 Claims. (Cl. 313-54)

This invention relates generally to charged particle generating systems and methods and more particularly to methods of and means for employing radioactive emitters for providing monokinetic charged particle emission and beams.

Among the objects of the invention are to provide improved methods of and means for generating monokinetic charged particle radiation.

Another object is to provide improved methods and systems for utilizing radioactive emission for controlling the energy of charged particle beams.

A further object is to provide improved methods and means for generating charged particle beams of any desired shape.

A further object is to provide improved methods and means for employing monokinetic charged particle energy for sterilizing materials by directly bombarding the materials with high energy charged particles.

Another object is to provide improved methods of and means for generating monokinetic charged particle beams in response to thermionic, photo-emissive, or field emission cathodic radiation.

A still further object is to provide improved methods and means for providing monokinetic electron beams in electron image tubes, electron microscopes, electron diffraction cameras, and the like wherein radioactive emission provides constant accelerating potentials for an electron beam.

Another object of the invention is to provide improved electron beam devices having self-contained radioactive emissive accelerating voltage means.

In applicant's copending applications, Serial Nos. 679,081, filed June 25, 1946, now Patent No. 2,517,120; 679,082, filed June 25, 1946, now Patent No. 2,527,945; 679,083, filed June 25, 1946, now Patent No. 2,598,925; and 679,085, filed June 25, 1946, now Patent No. 2,552,050, there are provided radioactive means for primarily generating electrical energy derived directly from radioactive emission. In said applications, the collected radioactive emission provides an electrical voltage which may be applied to a load circuit. In other known prior art, radioactive material is mixed with thermionic emissive material in a thermionic tube cathode to initiate electron flow.

In electron optical devices such as electron microscopes, infra-red devices such as electron image tubes, and the like, it has been necessary to provide accurately controlled unidirectional accelerating potentials for the generated electron beams. Such accurately controlled accelerating voltages require bulky and complex regulating circuits which greatly increase the cost of the associated apparatus. It is the purpose of the instant invention to provide a self-contained radioactive high voltage supply within the charged particle gun, the image tube, electron microscopes or the like, which will provide constant accelerating potentials and hence monokinetic charged particle beams. The only additional apparatus involved is the addition of a radioactive coated electrode within the tube

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or microscope electron gun structure which provides the required accelerating potentials. Various suitable radioactive charged particle emitters are known to provide the desired potentials. A number of these materials are listed in said copending application Serial No. 679,081.

The invention will be described in greater detail by reference to the accompanying drawings in which:

Fig. 1 is a fragmentary cross-sectional, partially schematic view of an electron gun according to the invention;

Fig. 2 is a cross-sectional elevational, partially schematic view of an infra-red responsive image tube in accordance with the invention;

Fig. 3 is a cross-sectional elevational, partially schematic view of an electron microscope according to the invention; and

Fig. 4 is a cross-sectional elevational, partially schematic view of an electron diffraction camera according to the invention.

Similar reference characters are applied to similar elements throughout the drawings.

Referring to Fig. 1, a charged particle beam device, suitable for electron optical, charged particle beam generating, food sterilizing, and the like purposes, provides constant velocity charged particle emission in accordance with the teachings of the invention. An evacuated, or gas-filled, envelope 1 includes a thermionic cathode 2 energized by an external power source, such as the battery 3. Electrons emitted from the cathode 2 are focused into a beam of desired cross-section by means of a Wehnelt cylinder, or other focusing device 4, which is maintained substantially at cathode potential. The electron beam 5 passing through the aperture 6 of the focusing device 4 is projected through an accelerating electrode 7. The accelerating electrode 7 may be toroidal in form as illustrated, or any other desired shape, to provide the desired electron optical focusing characteristics. A coating of radioactive charged particle emissive material 8 is applied preferably to the outer surface of the accelerating electrode 7. The electrode 7 is connected to cathode potential through a suitable resistor 9. The value of the resistor is determined by the particular type and quantity of radioactive material employed to provide the desired operating voltage, which will be controlled by the leakage current through the resistor 9. Radioactive emission from the accelerating electrode 7 will be collected upon a collector electrode 10 surrounding the accelerating electrode 7 and connected to the cathode 2.

If the radioactive coating 8 is a beta-ray emitter, the radiated electrons (beta rays), will be collected by the collector electrode 10. Thus the accelerator electrode 7 will be raised to a positive potential with respect to a cathode, the potential being determined by the product of the current and the resistance 9. As soon as the current through the resistor 9 has reached an equilibrium value, determined by the type and quantity of radioactive material employed, the accelerating potential on the accelerating electrode 7 will reach a constant value. The resulting constant accelerating potential will thereby provide a monokinetic electron beam 5 which may be utilized as desired. It should be understood that if a positively charged monokinetic beam is desired, the radioactive material should be selected to provide positively charged (alpha-ray) radiation, so that the resultant charge on the accelerating electrode will be negative with respect to the positive beam particles. The same principles may be employed to charge a "reflector" or "impeller" electrode positively or negatively, as desired. Also, if the beta emitter is on the element 10 and the beta-particles are collected by the element 7, the latter will be charged negatively and would accelerate positively charged beam particles.

Fig. 2 illustrates an exceedingly useful application of the invention to infra-red responsive electron image tubes of the type employed in "snooperscopes" or "sniperscopes." The evacuated envelope 11 includes a window 12, for projecting a desired infra-red or light image upon a photo emissive cathode 13. The image focused upon the photo emissive cathode 13 provides a corresponding electron image which may be projected along the tube and focussed upon a fluorescent screen 14 at the opposite end of the tube. The electron image emitted from the photo cathode 13 is progressively amplified by suitably proportioned accelerating potentials applied to a plurality of accelerating electrodes 15, 15a, 15b, 15c, 15d.

Said accelerating potentials are derived from a radioactive voltage generator enclosed within the photo emissive cathode structure 13. The radioactive material 8 preferably is coated upon a cylindrical element 16 which is supported adjacent to and coaxially within the photo-emissive cathode structure 13. Connections through the envelope of the tube from the elements 16 and 13 provide the positive and negative terminals of the accelerating potential source. These accelerating potentials are applied to the terminals of a voltage dividing potentiometer 17 having a plurality of adjustable contacts connected respectively to the accelerating electrodes 15, 15a, 15b, 15c, 15d, and to the fluorescent screen 14. If desired, for control of the maximum accelerating potential, an additional variable resistor element 18 may be connected in series with one of the accelerating potential terminals. The total leakage current through the voltage dividing resistor network 17, 18 will determine the accelerating voltages applied to the accelerating and screen collecting elements for the specific radioactive emissive material. Assuming that a beta-ray emitter is employed for the element 8, the photo-cathode will be charged negatively with respect to each of the progressively positive accelerating electrodes and with respect to the fluorescent screen 14. It should be understood that the voltage divider 17, 18 may comprise fixed resistive elements which may be enclosed entirely within the envelope 11, providing that external adjustment of the accelerating potentials is not desired.

Figure 3 illustrates the application of the invention to a conventional electromagnetic lens type electron microscope which is enclosed within an evacuated metallic envelope 21. Briefly, the electron microscope comprises an electron gun structure, to be described in greater detail hereinafter, an accelerating electrode or anode 7a, electromagnetic condenser, objective and projection lens 22, 23, 24, and a fluorescent screen 14 upon which an enlarged image of the specimen 25 is projected. The enlarged image on the fluorescent screen 14 may be observed through a viewing window 26. The specimen may be inserted or removed through a door 27. The electron beam generated by a point field emission cathode 28 is initially focused by the aperture 6 of a Wehnelt cylinder 4. The electron beam 5 is accelerated by the apertured anode 7a which is maintained at a high positive potential with respect to the cathode 28. The electromagnetic condenser lens 22 focuses the electrons in parallel beams, substantially coaxially with the central axis of the device, upon the specimen 25. The objective lens 23 located closely adjacent to and below the specimen 25 provides relatively high initial magnification of the electron image of the specimen, and this magnified image is additionally magnified and projected upon the fluorescent screen 14 by the projection lens 24.

The instant invention provides a convenient, simple, and inexpensive, constant high voltage power supply for the electron gun by utilizing the principles described heretofore by reference to Fig. 1. The point cathode 28 is supported at the neck of bottle-shaped collector electrode 10a in the center of the aperture 6 of the Wehnelt cylinder 4 which terminates the neck of said collector

electrode. Radioactive emissive material 8 is coated upon a spherical support 29 disposed concentrically within the collector electrode 10a. The elements 10a and 29 are maintained in concentric relation by a first insulator 30. The entire cathode-collector structure is maintained in suitable position with respect to the anode 7a by a second insulator 31 which permits external connection through the evacuated envelope to the radioactive emitter 8.

The radioactive emitter 8 is connected through a variable resistor 18 to the grounded envelope of the electron microscope and to the anode 7a and fluorescent screen 14. The radioactive material 8 is selected to emit beta-rays which charge the collector 10a and cathode 28 to a high negative potential with respect to the emitter 8, the anode 7a and the fluorescent screen 14. Thus the emitted electrons are accelerated through the apertured anode 7a and eventually impinge upon the fluorescent screen 14. The value of the accelerating voltage thus derived is determined by the total electron beam current, the particular type and quantity of radioactive material employed, and the adjustment of the external resistors 18, 19.

It should be understood that the cathode of the electron microscope may be of the thermionic emission type as described more particularly with respect to the structure of Figure 4. Either of the structures of Figs. 3 or 4 may employ either thermionic emissive or field emissive cathodes.

Referring to Figure 4, the invention is employed to provide the high voltage supply necessary for operating an electron diffraction camera. Briefly, the diffraction camera includes a thermionic cathode 2 and an apertured anode 7a for projecting an electron beam through a microspecimen to provide an electron diffraction pattern on a fluorescent screen. The high velocity electron beam derived from the cathode 2 and accelerated by the apertured anode 7a, is focused by an electromagnetic lens 32 through the microspecimen 25 to provide the desired electron diffraction pattern on the fluorescent screen 14 which may be observed through the viewing window 26.

The thermionic cathode 2 is energized by a suitable energizing source such as the battery 3, which may be controlled by a variable resistor 33. The initial electron emission from the point cathode 2 is focused by the central aperture 6 of the Wehnelt cylinder 4. The Wehnelt cylinder is maintained substantially at cathode potential.

The cathode structure is surrounded by a toroidal conductive element 34 having disposed and supported therein, but insulated therefrom, a ring shaped support 35 having radioactive material 8 coated thereon. If the radioactive material 8 is a beta-ray emitter, the electrons emitted therefrom are collected by the toroidal element 34 thereby raising the ring support 35 to a high positive potential with respect to the toroidal support 34 and the cathode 2. The ring shaped support 35 is connected to an external resistor 18 and thence to the anode 7a, the fluorescent screen 14 and the external metallic structure 21 of the device. As in the case of the electron microscope, the diffraction camera envelope 21 is highly evacuated.

The electron beam current through the device and the accelerating voltage will be determined by the type and quantity of radioactive material employed and by the adjustment of the external resistors 18, 19. As in all of the devices described heretofore, when the cathode is energized, the electron beam current and the accelerating voltage therefore will rise rapidly to a maximum value which will be determined by the type and quantity of radioactive material and by the leakage resistance in the radioactive current path.

Thus the invention described comprises improved methods of and means for utilizing radioactive emission for providing constant accelerating potentials for electron

beam devices. The potential source may be enclosed entirely within the electron beam devices requiring the accelerating voltage. External control of said voltage may be accomplished by variable resistive devices.

I claim:

1. Apparatus comprising, a first source of charged particles, accelerating means for charged particles produced by said first source including a radioactive source of charged particle emission disposed adjacent to said first source and collecting means for said radioactive emission for generating an accelerating potential on said accelerating means, and means for utilizing particles produced by said first source after acceleration by said accelerating means.

2. Apparatus comprising, a first source of electrons, accelerating means for electrons produced by said first source including a radioactive source of charged particle emission disposed adjacent to said first source and collecting means for said radioactive emission for generating an accelerating potential on said accelerating means, and means for utilizing electrons produced by said first source after acceleration by said accelerating means.

3. Apparatus comprising, a first source of electrons, accelerating means for electrons produced by said first source including a radioactive beta-ray source of negatively charged particle emission disposed adjacent to said first source and collecting means for said radioactive emission for generating a positive accelerating potential on said accelerating means, and means for utilizing electrons produced by said first source after acceleration by said accelerating means.

4. Apparatus comprising, a first source of positively charged particles, accelerating means for said first positively charged particles including a radioactive alpha-ray source of positively charged particle emission disposed adjacent to said first source and collecting means for said radioactive emission for generating a negative accelerating potential on said accelerating means, and means for utilizing positively charged particles produced by said first source after acceleration by said accelerating means.

5. Apparatus according to claim 3 including means for controlling said accelerated electron beam to provide an electron image.

6. Apparatus according to claim 3 including means for controlling said accelerating potential.

7. Apparatus according to claim 3 wherein said first electron source is a thermionic cathode.

8. Apparatus comprising, an envelope containing a first source for producing charged particle emission, and a radioactive charging unit including a source of radioactive charged particle emission and a collector electrode spaced therefrom for collecting said radioactive emission, one of the elements of said radioactive charging unit being disposed in said envelope in spaced relation to said first source to provide an accelerating field for particles produced by said first source.

9. Apparatus comprising, an envelope containing means for generating an electron beam, an accelerating electrode within said envelope spaced from said electron beam generating means in the direction of electron travel, a radioactive emitter on said accelerating electrode providing negatively charged radioactive emission, and a further electrode spaced from said accelerating electrode for collecting said radioactive emission whereby a positive accelerating potential is generated on said accelerating electrode.

10. Apparatus as claimed in claim 9 wherein said accelerating electrode is apertured and said electron beam is accelerated through the aperture in said electrode.

11. Apparatus comprising, an envelope containing means for generating an electron beam, an accelerating electrode within said envelope spaced from said electron beam generating means in the direction of electron travel, a further electrode spaced from said accelerating electrode, and a radioactive emitter on said further electrode providing positively charged radioactive emission, said accelerating electrode collecting said radioactive emission to generate a positive accelerating potential on said accelerating electrode.

12. Apparatus as claimed in claim 10 wherein said accelerating electrode is apertured and said electron beam is accelerated through the aperture in said electrode.

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