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M. C. CROWLEY-MILLING

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TREATMENT OF MATERIALS BY ELECTRONIC BOMBARDMENT

Filed Jan. 17, 1955

2 Sheets-Sheet 1

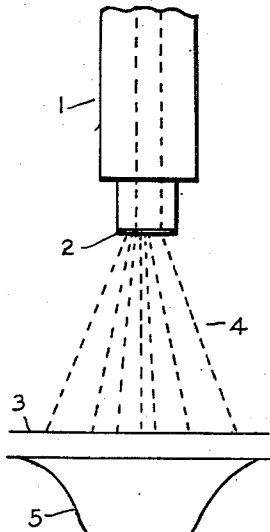


Fig. 1

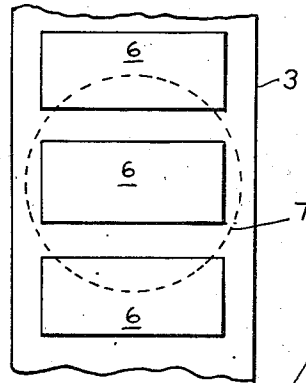


Fig. 2

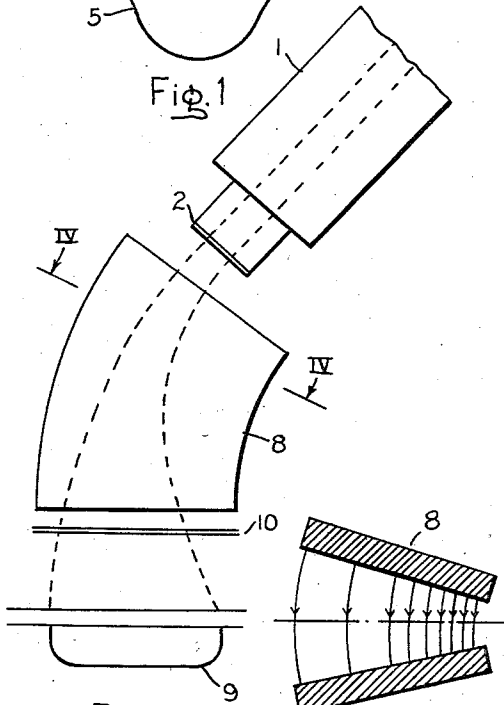


Fig. 3

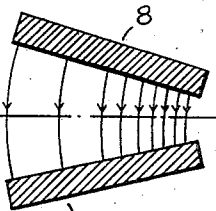


Fig. 4

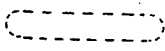


Fig. 5

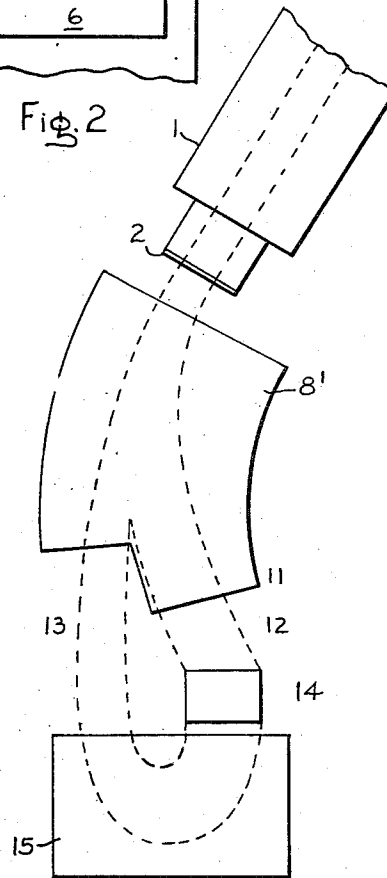


Fig. 6

INVENTOR
Michael Crowley Crowley-Milling
By Harris & Potters
ATTORNEYS

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M. C. CROWLEY-MILLING

2,824,969

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2 Sheets-Sheet 2

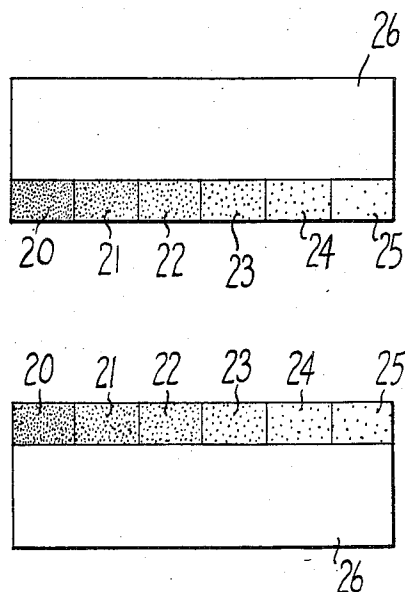


Fig. 7

INVENTOR

Michael C. Crowley-Milling

By *Woods & Peterson*

ATTORNEYS

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2,824,969

TREATMENT OF MATERIALS BY ELECTRONIC BOMBARDMENT

Michael Crowley Crowley-Milling, Colwyn Bay, Wales, assignor to Metropolitan-Vickers Electrical Company Limited, London, England, a company of Great Britain

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Claims priority, application Great Britain February 1, 1954

6 Claims. (Cl. 250—49.5)

This invention relates to the irradiation of material by electronic bombardment and has an important application in the sterilisation of foods, chemicals, and medical and surgical apparatus, and the like.

It has been found that high energy electron beams are capable of penetrating substances to a considerable depth and in doing so are effective in destroying living organisms such as bacteria. The sterilisation action of high energy electron beams is extremely rapid and hence articles and materials to be sterilised can be processed in a continuous flow movement across the electron beam.

Examples of apparatus suitable for producing such an electron beam are linear accelerators, the Van de Graaff generator and the betatron.

In applying such apparatus for this purpose it is usual to provide the vacuum enclosure with a window consisting of thin metallic foil hermetically sealed to the surrounding wall of the vacuum chamber, which foil must be strong enough mechanically to withstand the atmospheric pressure but at the same time sufficiently thin to permit of the passage of the greater part of the electron beam.

It will be appreciated, however, that the passage of the beam through such a window will cause a certain amount of scattering depending upon the thickness of the window and the density of the foil material.

Since the original beam is normally of approximately circular cross-section the area irradiated will also be approximately circular. However, in many cases a circular cross-sectional shape is unsuitable, for instance, in cases above instanced in which the material to be irradiated moves continually across the beam, it follows that parts at the centre will cross the full diameter of the beam and hence receive a much larger dose than the parts at the side which will only intersect a sector of the beam. This unequal dosage is accentuated by the fact that the intensity of the beam is not uniform but is greatest at the centre and reduces towards the edges.

The main object of the invention is to provide an improved arrangement for providing a beam, the cross-sectional shape of which is elongated so that its dimension along the direction of movement of the materials being treated will be substantially uniform.

According to the present invention an electron beam emitter has means for projecting the electron beam through a magnetic field whereby the beam is deflected laterally so as to traverse a curved path and is also spread laterally in the plane of curvature so that the resultant beam has an elongated cross-section.

Preferably the deflecting field is produced between a pair of flat faced pole pieces which are splayed outwardly so that their separation is greatest and hence the field weakest towards the outside of the curvature of the electron path.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings, in which:

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Fig. 1 shows diagrammatically the beam normally produced by a high voltage electron accelerator; whilst

Fig. 2 is a plan view of a moving belt carrying objects to be irradiated, and indicates the area affected by the beam;

Fig. 3 shows a side view of apparatus embodying the invention; whilst

Fig. 4 is a section on the line IV—IV of Fig. 3;

Fig. 5 shows approximately the shape of beam which can be produced with this apparatus;

Fig. 6 shows a modified form of the apparatus shown in Fig. 3.

Fig. 7 shows a design of pole pieces alternative to those shown in Fig. 3 and Fig. 4.

Referring first to Fig. 1, the reference 1 indicates the end of an electron accelerator such as a linear accelerator having a metal foil window 2. The emerging beam is shown as falling on a surface 3 and the propagation of the beam is indicated by the dotted lines 4. The line 5 indicates graphically the distribution of intensity across a section of the beam and it will be observed that the intensity is greatest at the centre of the beam and reduces appreciably towards the edges.

Fig. 2 shows a plan view of the beam of Fig. 1 in which the rays are projected vertically downwards on to the surface 3 which is shown as a carrier for materials being treated, the materials being in the form of rectangular objects 6. The shape of the beam, however, as above explained, will be circular, as indicated by the dotted line 7, and it will be readily appreciated that with a beam of the shape shown in Fig. 2, and intensity distribution as shown in Fig. 1, the material along the centre of the conveyor surface 3 will be treated to a much greater extent than that at the outsides of the rectangles.

Figs. 3 and 4 show the improved arrangement embodying the invention. In this drawing, the reference 1 again indicates the outlet end of a linear accelerator having a window 2, whilst the electrons, after leaving the window 2, pass between the pole pieces 8 of a magnet system. These will deflect the beam so that it will follow a curved path, as indicated in the drawing. Whilst the pole pieces are also splayed outwardly, as shown more clearly in Fig. 4, with the result that the magnetic field density is greatest on the inside of the curve and reduces progressively towards the outside of the curve, this will have the effect of elongating the beam in the plane of curvature so that it will ultimately have a shape somewhat as indicated in Fig. 5 and the distribution of intensity will be as indicated by the curve 9 underneath Fig. 3. In some cases it may be desirable to insert a second metallic foil 10 in order further to scatter the beam if in elongating the section of the beam in lateral direction too narrow a strip results due to the focusing action of the non-uniform magnetic field in the plane at right angles to that in which the beam is being spread.

In treating materials which are of appreciable thickness it may be found that the electrons only partially penetrate the material and a further feature of the invention consists in splitting the beam into two component beams and applying one component to one side of the material and the other component to the opposite side. A modified arrangement for doing this is shown in Fig. 6 in which the magnet pole pieces 8' are elongated at 11 on the inside of the curve and are so shaped that the beam is split into two component beams 12 and 13, of which the beam 12 bombards the top surface of the material 14, whilst the other half of the beam 13 passes between further magnetic poles, indicated at 15, whereby it is deflected through approximately 180° and bombards the lower surface of the material 14. The field produced

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by the poles 15 may be uniform, or, if it is desired to shape the beam further, non-uniform.

It will be appreciated that in the arrangement shown the pole pieces 8 may either be pole pieces of permanent magnets or of electro-magnets.

Whilst in the arrangement shown the non-uniform magnetic field has been obtained by the splaying out of the pole pieces, giving an approximately linear variation of field with displacement from the mean path, it may be desirable to have this variation other than linear, to achieve any desired variation of intensity across the beam of electrons, and this may be done by shaping the pole pieces, inserting material of graded magnetic reluctance 20, 21, 22, 23, 24 and 25 between parallel pole pieces 26, as shown in Fig. 7, and so forth.

What I claim is:

1. An electron beam emitter apparatus comprising means for projecting an electron beam, a magnet for producing a magnetic field across said beam to cause said beam to follow a curved path, pole pieces to said magnet having a separation which decreases progressively towards the centre of curvature of the beam whereby the beam's cross-section is elongated in the plane of curvature, means for splitting the electron beam into two component beams separated in the plane of curvature, and means for producing a second magnetic field across one of said component beams so as to deflect it through an angle of approximately 180°.

2. Apparatus for irradiating objects with electrons, comprising means for projecting an electron beam, a magnet for producing a magnetic field across said beam to cause said beam to follow a curved path, pole pieces to said magnet having a separation which decreases progressively towards the centre of curvature of the beam whereby the beam's cross-section is elongated in the plane of curvature, means for splitting the electron beam into two component beams separated in the plane of curvature, and means for producing a second magnetic field across one of said component beams so as to deflect it through an angle of approximately 180°, so that in operation objects may be irradiated on two opposite sides by said two component beams.

3. Apparatus for irradiating objects with electrons, comprising means for projecting an electron beam, a magnet for producing a magnetic field across said beam to cause said beam to follow a curved path, pole pieces for said magnet having a separation which decreases progressively towards the centre of curvature of the beam whereby the beam's cross-section is elongated in the plane of curvature, material of graded magnetic reluctance inserted between said pole pieces to assist in controlling the intensity of the electron beam over its cross-section, and a conveyor to transport the objects through said electron beam.

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4. Apparatus for irradiating objects with electrons, comprising means for projecting an electron beam, a magnet for producing a magnetic field across said beam to cause said beam to follow a curved path, pole pieces for said magnet having a separation which decreases progressively towards the centre of curvature of the beam whereby the beam's cross-section is elongated in the plane of curvature, material of graded magnetic reluctance inserted between said pole pieces to assist in controlling the intensity of the electron beam over its cross-section, means for splitting the electron beam into two component beams separated in the plane of curvature, and means for producing a second magnetic field across one of said component beams so as to deflect it through an angle of approximately 180°, so that in operation objects may be irradiated on two opposite sides by said two component beams.

5. Apparatus for irradiating objects with electrons, comprising means for projecting an electron beam, a magnet for producing a magnetic field across said beam to cause said beam to follow a curved path, pole pieces for said magnet having a separation which decreases progressively towards the centre of curvature of the beam and which are elongated on the inside of the plane of curvature of the beam whereby the beam is split into two component beams separated in the plane of curvature, and the beam's cross-section is elongated in the plane of curvature, material of graded magnetic reluctance inserted between said pole pieces to assist in controlling the intensity of the electron beam over its cross-section, means for producing a second magnetic field across one of said component beams so as to deflect it through an angle of approximately 180°, so that in operation objects may be irradiated on two opposite sides by said two component beams, and a conveyor to transport said object through said component electron beams.

6. Apparatus for irradiating objects with electrons, comprising means for projecting an electron beam, a magnet for producing a magnetic field across said beam to cause said beam to follow a curved path, pole pieces having a separation which decreases progressively towards the centre of curvature of the beam whereby the beam's cross-section is elongated in the plane of curvature and a conveyor to transport said objects through said electron beam.

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