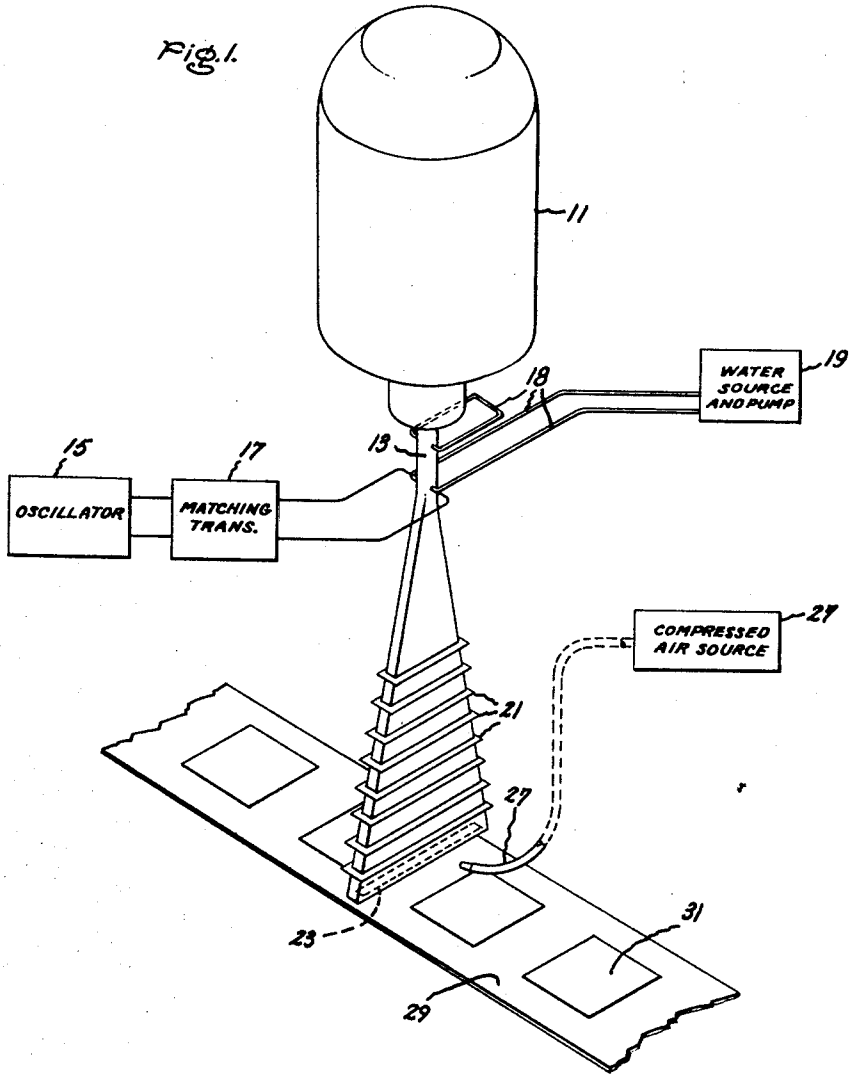
Nov. 22, 1960 W. F. WESTENDORP 2,961,561

INTERNAL MAGNETIC DEFLECTION SYSTEM FOR ELECTRON BEAM GENERATOR

Filed Oct. 29, 1957

3 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

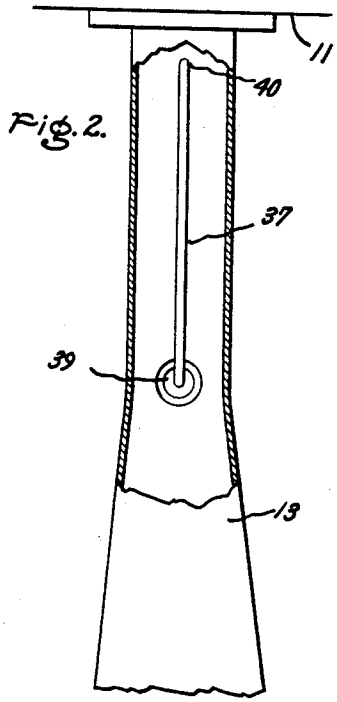
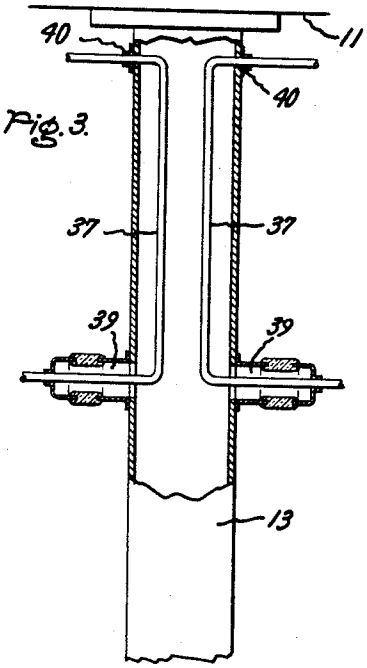
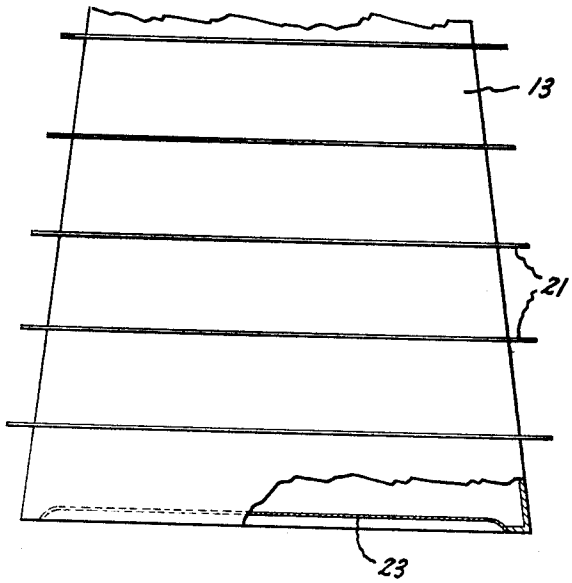
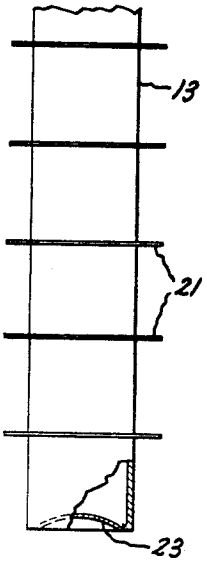


Fig. 3.







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INTERNAL MAGNETIC DEFLECTION SYSTEM FOR ELECTRON BEAM GENERATOR

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Fig. 4.

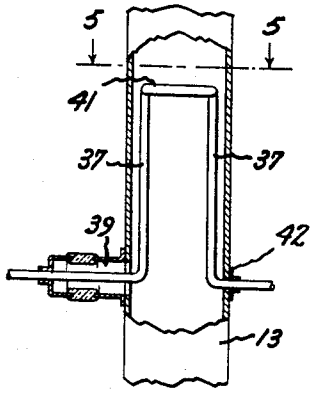


Fig. 5.

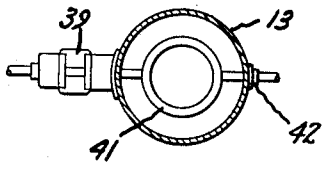


Fig. 6.

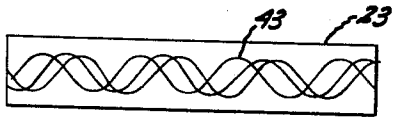
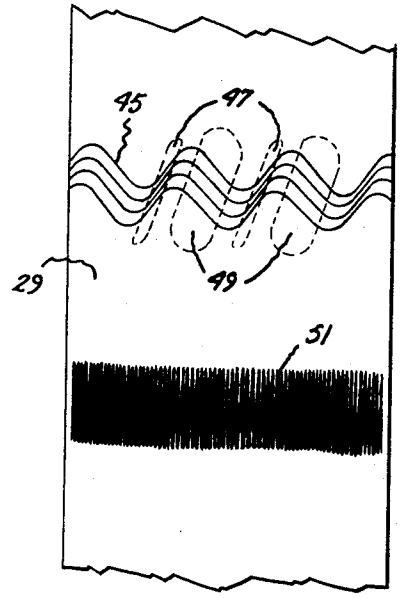


Fig. 7.



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2,961,561

INTERNAL MAGNETIC DEFLECTION SYSTEM FOR ELECTRON BEAM GENERATOR

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Filed Oct. 29, 1957, Ser. No. 693,201

8 Claims. (Cl. 313—74)

The present invention relates to an electron beam generator and a deflection system therefor, and more particularly to a deflection system mounted within an electron beam generator.

Electron beam generators having accelerating voltages in the order of several millions of volts are being used for the irradiation of organic and inorganic materials, for the sterilization of food, for experimental purposes, etc. In these generators the extension chamber, which is the generator component through which the electron beam passes last, has a thin rectangular window at an end thereof constructed of a metal made thin enough to pass electrons. The material to be irradiated is placed on a continuous belt running beneath this window and is irradiated by the electron beam which is deflected over the material transversely with respect to the direction of movement of the belt.

As the electron beam passes through the metal window the electrons are scattered to some extent with a consequent heating of the window. This heating if extended only over a line, as in the case with only a transverse deflection, produces local overheating with consequent weakening and oxidation of the metal which results in punctures that destroy the vacuum seal otherwise provided by the window. Cooling means such as blasts of air directed along the window are being used but they are not sufficient in themselves to conduct away enough heat to prevent adverse heating effects.

Accordingly, an object of my invention is to provide an electron beam generator in which the window is not heated to a destructive temperature.

Window heating can be reduced by spreading the energy from the beam over a large area of the window instead of concentrating it along a line. Then, although all of the window is heated, no region is heated to a temperature that produces oxidation or weakening of the metal.

Thus, another object is to provide an electron beam generator in which the beam is spread over a relatively large area of the window to obviate localized heating.

This heating can be spread over the window by cross deflecting the beam; i.e., by deflecting the beam perpendicularly to the principal deflection. A magnetic cross-deflection system is preferably used because an electrostatic deflection system requires large voltages to deflect the high beam currents, which voltages introduce severe insulation requirements. Electromagnetic windings cannot be used because if placed inside the extension chamber they contaminate the vacuum and if placed outside, the required field must be very great to penetrate the extension chamber because of eddy current effects in the extension chamber walls. Of course the generator could be extended to permit placing of the deflection windings on the glass portion of the generator usually situated in the transformer region. But since the generator is very long, it is undesirable to increase its length.

Therefore, a further object of the present invention is to provide an effective magnetic cross-deflection system

for an electron beam generator that does not add to the length of the generator and does not contaminate the vacuum therein.

The use of a cross-deflection system although providing better heat spreading at the window may distribute the beam non-uniformly over the irradiated materials.

Thus, still another object is to provide a cross-deflection system that distributes the electron beam uniformly over the irradiated materials.

I obtain these and other objects in one embodiment of my invention by the provision of two water-cooled conductors mounted in the interior of and substantially parallel to the axis of an extension chamber of an electron beam generator. These conductors are energized in series by an alternating current having a frequency of the order of 1000 times as great as that of the principal deflection to produce a very rapid cross-deflection of the electron beam.

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood by refernce to the following drawings in which:

Fig. 1 is a diagrammatic illustration of an electron beam generator system of the present invention,

Fig. 2 is an enlarged partial front view, partly in cross-section, of the extension chamber of the system of Fig. 1,

Fig. 3 is an enlarged partial side view, partly in cross-section, of the extension chamber of the system of Fig. 1,

Fig. 4 is an elevational view of another embodiment of the cross-scan deflection system of the present invention,

Fig. 5 is a top view of the embodiment of Fig. 4, taken along line 5—5 looking in the direction of the arrows,

Fig. 6 is a trace pattern of the electron beam obtainable with the deflection system of the present invention, and

Fig. 7 illustrates trace patterns obtainable on the irradiated material.

Referring now specifically to Fig. 1, I have shown an electron beam generator comprising an envelope **11** containing the beam forming structure, the transformer for providing accelerating voltages and the conventional focus and deflection systems for the beam. Such structures may be conventional in form and hence are not illustrated. An extension chamber **13** extends beneath envelope **11** and includes an elongated neck and a flanged region permitting transverse movement of the electron beam which is produced by the principal deflection system.

The cross-deflection system of the present invention includes a high frequency oscillator **15** for producing an output current having a frequency preferably of the order of 1000 times as great as the principal deflection frequency, which current is coupled through a matching transformer **17** to conductors (to be described later) mounted within the neck of extension chamber **13**. These conductors are preferably made hollow so that they can be cooled by a cooling medium such as water pumped through pipes **18** to and from a water source and pump **19**.

The flanged region of the evacuated extension chamber **13** is strengthened by a plurality of fins **21** so that the chamber walls do not collapse from the air pressure. At the bottom end of the flanged portion a thin window **23** constructed of a metal such as titanium passes electrons while providing a vacuum seal. This window is preferably cooled by air from a compressed air source **25** flowing through a nozzle **27** illustrated as producing

an air flow from one point, but that preferably extends along the length of the window for more effective action.

A continuously running conveyor belt **29** passes beneath extension chamber **13** transversely to the wedge-shaped region so that the material **31** thereon is scanned transversely by the beam. Of course, as this material moves transversely to the principal deflection of the beam, its total area is irradiated.

In Fig. 2 I have provided an enlarged cross-section of the extension chamber **13** to illustrate one of the conductors **37** that is mounted at one end by means of an insulator **39** to extend approximately parallel to the axis of the neck of extension chamber **13**. The other end is mechanically and electrically secured at point **40** to the wall of the neck by brazing or the like to extend through the wall thereby permitting the connection of a pipe to it for providing either an inlet or outlet for a cooling fluid. Also, in this figure the window **23** can be seen as bowed due to the difference in pressures on its two faces.

Both conductors **37** are illustrated in Fig. 3. They are approximately parallel to and at the same distance from the axis of the neck of the extension chamber **13** and are mechanically and electrically connected at points **40** at the same ends and at their other ends are connected through insulators **39**, which are preferably Kovar seals, to the exterior of the extension chamber. Extension chamber **13** being electrically connected to conductors **37** provided means for conducting electrical current from one conductor to the other thereby permitting a series energization of these conductors.

Fig. 4 illustrates an embodiment of my invention requiring only one insulator **39** and only one mechanical and electrical connection to extension chamber **13**. The principal distinction between this and the prior embodiment is the mechanical and electrical connection of two ends of the conductors **37** by a hollow ring **41** that also provides a path for the cooling substance to flow from one conductor to the other. While both conductors can be brought out through insulators, preferably one is joined mechanically and electrically at point **42** to the extension chamber which then functions as a ground potential for the electrical signals.

As is better seen in Fig. 5, ring **41** encircles the extension chamber axis along which the electron beam travels. Magnetic fields produced by currents in the ring have no effect upon the beam, for the axial magnetic fields from one half of the ring cancel fields from the other half. Although the connecting element can also be semicircular in shape in that case the magnetic field is not canceled. However, this has little effect on the beam due to the short length of the connecting element and the substantially parallel relationship between beam and field.

The operation of both disclosed embodiments is substantially the same. During one half cycle of the alternating current from oscillator **15**, current flows in opposite direction in the two conductors **37**. During the other half cycle the direction of current flow is reversed. The flux produced by the current flow encircles the conductors to produce a resulting field which is parallel to the long dimension of the window **23** and alternately reverses in direction upon reversals of current. This field deflects the beam at right angles along the narrow dimensions of window **23** to produce at low frequencies a pattern somewhat like that appearing as trace **43** in Fig. 6. The frequency of the oscillator **15** is preferably not a harmonic of the normal deflection frequency so that the cross-deflection cycles of successive traces are out of phase thereby giving overlapping traces. Consequently, heating produced by the beam is spread over the window rather than being concentrated along a line as in prior systems.

A relatively low deflection frequency of the order of 10 times that of the normal deflection frequency, while being suitable to prevent overheating of the window is inadequate to ensure uniform irradiation of the material. For example, in Fig. 7 traces **45** illustrate a possible distribution pattern when the cross-deflection frequency is very low, i.e., 1000 or 2000 cycles per second. As the belt **29** moves along, each trace pattern is displaced slightly from the previous pattern due to the non-harmonic relationship between the output of the oscillator **15** and the transverse deflection of the beam. Some regions, such as **47**, have a greater amount of irradiation per unit area of material than other regions, such as **49**. Of course, uniform irradiation is usually desired. Uniform irradiation is always produced if the frequency of oscillator **15** is of the order of 1000 times that of the transverse deflection frequency. Then the distance between successive cycles of the cross-deflection on the irradiated material is of the order of the beam width. While an attempt has been made to illustrate the trace patterns on the material by lines **51** actually the resultant coverage is more in the nature of a general overall background rather than any distinct trace pattern. It is evident that such a pattern provides uniform irradiation regardless of whether or not the oscillator frequency is a harmonic of the normal scan frequency.

At such high cross-deflection frequencies the reactance of conductors **37** is not objectionable. For example, in one completed embodiment utilizing a cross-deflection frequency of 100,000 cycles per second and having conductors with a total length of approximately 50.8 cm., the reactance was 0.114 ohm. To illustrate the heating, the current was such that the voltage drop across the conductors, which had a Q of 10, was approximately 6½ volts, and thus approximately 40 watts were dissipated in them. Of course the cooling water removed most of this heat.

As should be evident from the above discussion, a cross-deflection system has been provided for producing spreading of the heating of the window over a large area and for producing uniform irradiation of material. Conductors **37** can be made of stainless steel so that they do not contaminate the vacuum as would deflection windings. Further, because these conductors are contained within the extension chamber, no flux penetrates the chamber walls and thus there is substantially no eddy current loss.

Although I have described my invention with respect to certain specific embodiments, it will be appreciated that many modifications and changes may be made by those skilled in the art without departing from the spirit of my invention. I intend, therefore, by the appended claims to cover all such modifications and changes as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an electron beam generator having an extension chamber through which the electron beam passes, a cross-deflection system for producing a magnetic deflection field comprising two serially connected elongated conductors mounted within said extension chamber on opposite sides of and parallel to the axis of said chamber.

2. In an electron beam generator of the type having an extension chamber with an elongated neck along which an electron beam is projected and deflected in one direction at a desired frequency, a magnetic cross-deflection system comprising two serially connected elongated conductors mounted within said extension chamber on opposite sides of and parallel to the axis of said neck, and means for energizing said conductors with an alternating current having a frequency of the order of 1000 times the desired deflection frequency in said one direction.

3. The cross-deflection system as defined in claim 2 wherein said two conductors are hollow, and means for supplying a cooling medium to said hollow conductors.

4. In an electron beam generator for irradiating a piece of material with an electron beam having an extension chamber, a magnetic cross-deflection system for deflecting the beam in a direction perpendicular to the direction of

principal deflection comprising two serially connected elongated conductors mounted within said extension chamber on opposite sides of and substantially parallel to the axis of said chamber, means for energizing said conductors with an alternating current having a frequency which is high compared to the frequency of principal deflection so that the distance between successive trace patterns of the cross-deflection cycles on the irradiated piece of material is of the order of the diameter of the electron beam.

5. In an electron beam generator, a magnetic cross-deflection system comprising an elongated extension chamber having first and second opposed insulators, a first elongated conductor within said chamber having one end connected through said first insulator and another end electrically and mechanically connected to said extension chamber to extend inside of said chamber substantially parallel to the axis thereof, and a second elongated conductor within said chamber having one end connected through said second insulator and another end electrically and mechanically connected to said extension chamber to extend inside said chamber substantially parallel and opposed to said first conductor.

6. In an electron beam generator having an elongated extension chamber, a magnetic cross-deflection system comprising a first elongated conductor having two ends, an insulator mounted in said extension chamber for securing one end of said first conductor so that said first conductor extends in said extension chamber approximately parallel to the axis on one side thereof, a second elongated conductor having two ends, means for electrically and mechanically securing one end of said second conductor to said chamber opposite the insulated end of said first conductor so that said second conductor extends in said extension chamber in opposed and substantially parallel relationship with said first conductor, and a ring-

shaped conductor within said extension joining the two other ends of said first and second conductors in electrical and mechanical relationship.

7. In an electron beam generator of the type having an extension chamber with an elongated neck along which an electron beam is projected and deflected at a desired frequency for irradiating a material, a magnetic cross-deflection system comprising two serially connected elongated conductors mounted within said chamber on opposite sides of and parallel to the axis of said neck, and means for energizing said conductors with an alternating current of a frequency to produce cross-deflection of said beam such that the distance on the irradiated material between successive cycles of the cross-deflection is of the order of the width of said beam.

8. Electron beam generating apparatus including a vacuum tight envelope, means within said envelope for generating and directing a beam of high energy electrons toward an end of said envelope, said envelope being shaped to permit deflection of said beam in mutually perpendicular directions over said end of said envelope and magnetic deflection means for deflecting said beam in one of said directions including a pair of elongated conductors supported within said enclosure and extending on opposite sides of the beam and in parallel relation to the direction thereof.

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