United States Patent

[11] 3,624,391

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[21] Appl. No. **29,231**
[22] Filed **Apr. 16, 1970**
[45] Patented **Nov. 30, 1971**

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[32] Priority **Apr. 16, 1969**
[33] **Great Britain**
[31] **19,316/69**

[54] **WINDOW STRUCTURE FOR ELECTRON BEAM IRRADIATION**
8 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** ..... **250/49.5 TE,** 250/52, 313/74
[51] **Int. Cl.** **H01j 37/30**
[50] **Field of Search** ..... 250/49.5 TE, 49.5 R, 52; 313/74

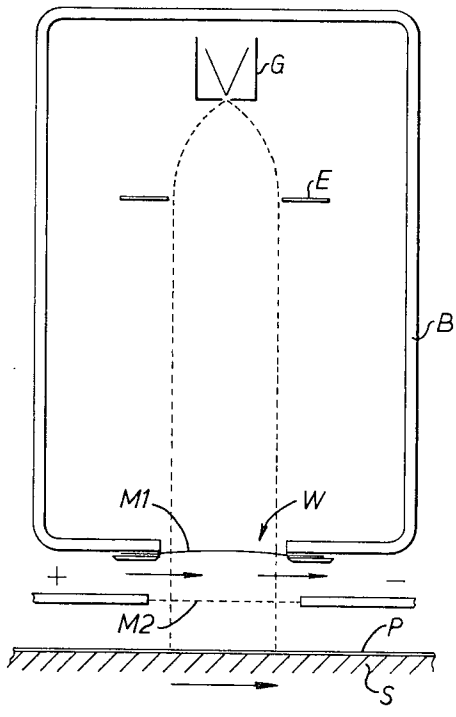
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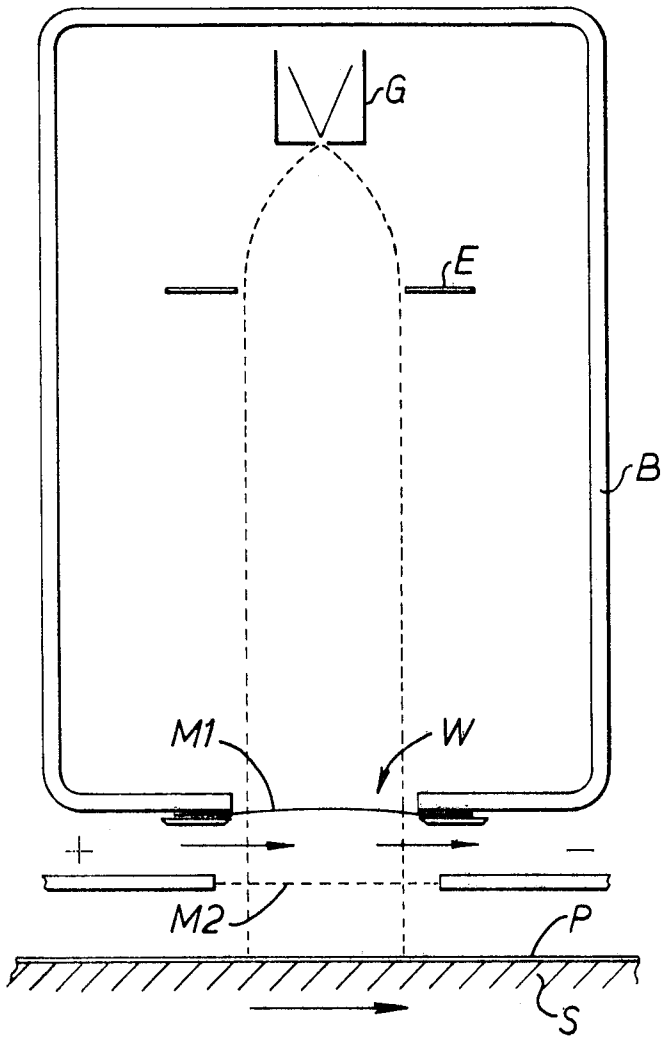
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ABSTRACT: For electron beam irradiation apparatus in which electrons generated in an evacuated chamber emerge through a cooled pressuretight window to impinge on the material under treatment a window structure comprises two spaced membranes, one of which is gastight to withstand the pressure difference and the other is permeable to both gas and electrons but prevents a cooling gas passed between the membranes from disturbing the surface of the material.




G
E
B
M1
W
+
−
M2
P
S

WINDOW STRUCTURE FOR ELECTRON BEAM IRRADIATION

This invention relates to apparatus for carrying out irradiation by the use of a beam or beams of electrons, and in particular to the construction of a window through which the electrons pass from the region of high vacuum in which they are generated to the region of lower vacuum (usually atmospheric pressure) in which the material to be irradiated is disposed. Although arrangements are known in which there is no physical barrier but simply a series of pumped apertures or slits through which the beam passes, this is only practical for very narrow beams and requires substantial, high-capacity pumping equipment. It is usual to provide a window of foil, for example of titanium or aluminum, thick enough to withstand the pressure difference across it but not thick enough to absorb an undue proportion of the electrons passing through it. The conflict between these requirements of adequate strength and minimum electron absorption are particularly acute where, for economic reasons, electrons of relatively low energy (say below 500 kv.) are employed. The proportion absorbed is approximately proportional to the mass thickness of the window and increases as the electron energy decreases.

The greater the degree of absorption the greater is the amount of heat generated in the window itself, and it is known to use peripheral cooling and/or to pass a rapid flow of air or other gas across the external surface of the window to carry the heat away.

In many cases it is necessary anyway to arrange for a flow of gas between the window and the material to be irradiated, to remove heat, radiation products (such as ozone and oxides of nitrogen) and volatile products. Where the material to be irradiated is a liquid or semiliquid, for example a viscous coating, it is advisable to arrange that the gas flow has only a small velocity relative to the material, for example by passing the gas in the same direction as the material and at a comparable speed.

One of the limitations on the use of a gas flow for window cooling is the difficulty of obtaining a sufficiently high rate of cooling without disturbing the liquid coating and so spoiling the appearance of the coated product. One way already proposed has been to provide a double window, i.e. with two membranes or foils spaced apart, and to pass a flow of gas between them at a high rate. However, the presence of the second foil still further increases the absorption, and consequently reduces the useful penetration of the emerging electrons or conversely calls for higher initial energies for a given application.

According to the invention we now propose to provide a window comprising a first membrane which is impermeable to gas (and across which the pressure difference is withstood) and a second "membrane" which is spaced from the first but is permeable, both to air and electrons. A flow of cooling gas is passed transversely through the space between the permeable and impermeable membranes.

In this way the flow of cooling gas is largely confined between the two membranes and prevented from disturbing the surface of the material being irradiated, yet at the same time a proportion of the electrons only have to pass through one effective foil. To reduce the net flow of gas through the permeable membrane we preferably arrange that the transverse flow is effected by the presence of an excess pressure at one side of the window structure and an approximately equal negative pressure at the other, so that the mean pressure at the center of the membrane is comparable with or slightly below that on the other side of it (i.e. in most cases atmospheric).

The invention will now be further described by way of example with reference to the accompanying drawing which illustrates diagrammatically a section through the window and indicates also the related components.

Indicated at G is a source of electrons, which are formed into a beam by an electrode system indicated diagrammatically at E. This system accelerates the electrons to give them an energy of, for example, 200 Kev. The beam is only partially focused, so it has a relatively large cross section as it emerges

from the evacuated chamber B, in which it is generated, through a window structure W. This window structure comprises two membranes M1 and M2 spaced apart in the direction of travel of the electrons, the first one being impermeable to gas and as thin as possible consistent with being able to withstand the pressure differential between atmosphere and the vacuum within the chamber B. As the electrons are of relatively low energy their penetration is low and so it is important for the window to be thin and also to be of a material of low absorption, for example titanium or aluminum.

The second membrane M2 is not gastight but on the contrary is open construction, for example of wire mesh, or of perforated sheet, or a series of thin ribbons, or a combination of these. It may be of metal such as aluminum or titanium, nickel or stainless steel, or it could even be of a nonmetal as long as it is substantially unaffected, over a worthwhile life, by continuous electron beam irradiation.

The electrons pass through the second window M2 to impinge on the material to be irradiated; in the example illustrated this is a coating, for example of liquid paint P on a substrate S, and the action of the radiation is to cure the paint rapidly and without appreciable heating. The substrate with the coating on it, is moved continuously through the path of the beam.

The two membranes M1 and M2 define between them a passage through which a cooling gas is passed, as indicated by the arrows. This gas carries away the heat generated by the electrons in the membranes M1 and M2, but the presence of the membrane M2, even though it is not gastight, prevents any substantial unwanted flow close to the paint P such as might ripple its surface. Preferably the direction of flow of the gas is arranged to be parallel to and in the same direction as the direction of travel of the material being irradiated, so that any slight residual movement there might be in the atmosphere above the paint will at least be in the same direction.

A further measure that will reduce the gas flow through the membrane M2 is for the transverse flow to be caused by maintaining a pressure above atmospheric at one side of the window structure and a pressure an equal amount below atmospheric on the other side, (as indicated by the + and − signs) so that the mean pressure in the window structure is equal to atmospheric pressure. The cooling gas used may be air, or nitrogen, or any other suitable gas, including inert gases to eliminate corrosion.

The membrane M2 thus serves to prevent the flow of cooling gas upsetting the surface of the paint P to be irradiated yet at the same time its open structure ensures that it offers as little as possible resistance to the electrons. For the window structure to have an adequate overall efficiency of transmission the membrane M2 should be of a sufficiently open nature to absorb less than 50 percent, and preferably less than 30 percent, of the electrons incident on it; the apertures in it are preferably less that 5 millimeters across. The thickness of the solid portions of it, i.e. the ribbons or wires themselves, or the webs of sheet between the perforations may be such as to absorb substantially all the electrons that impinge on those parts, and in that case the membrane should be not less than 80 percent holes and 20 percent solid.

Preferably, however, even the solid parts of the membrane M2 are sufficiently thin so that the total mass thickness of the gastight membrane M1, the cooling gas and the solid parts of the membrane M2 amounts to less than half the range of the electrons used. This results in an improvement in the distribution of the electron dose throughout the thickness of the coating P in that the dose absorbed at the upper surface of the coating is increased relative to the total dose, without a reduction in the effective coating thickness than can be cured. That is to say, it is not necessary to give an excessive total dose, more than most of the thickness of the coating needs, to ensure that the dosage received by the surface layer reaches the minimum required. This surface layer is taken care of by those electrons that have had their energy very substantially reduced in passing through the window structure. In this case, that is to say, where even the solid parts of the second mem-

brane M2 are at least partially permeable to electrons, the degree of openess of its structure should be such that it is between 40 percent and 60 percent solid.

What I claim is:

1. A window structure for use in electron beam irradiation apparatus including an evacuated chamber in which electrons are generated, said window structure comprising a first membrane extending over an opening in the wall of said chamber in a position to receive electrons generated in said chamber, said membrane being substantially impermeable to gas but permeable to electrons and being constructed and arranged to withstand a pressure difference between the evacuated chamber and the atmosphere prevailing outside it, a second membrane spaced away from said first membrane to define therebetween a space for the passage of a cooling gas, and means for moving a cooling gas through said space, said second membrane being constructed and arranged of a low density material so as to be highly permeable to electrons and also permeable to gas, the gas permeability of said membrane being selected so as to impede movement of gas and consequent turbulence thereof through said second membrane from the space between it and said first membrane.

2. The apparatus set forth in claim 1 including means for moving a material to be irradiated past the outside of said window structure in the same direction as the flow of gas.

3. The apparatus set forth in claim 1, wherein said means for passing a flow of gas between the membranes comprise a source of positive pressure one side of the window structure and a source of equal negative pressure the other side of the window structure whereby the mean pressure prevailing between the membranes themselves is substantially equal to the pressure of the atmosphere prevailing outside said second membrane.

4. The apparatus set forth in claim 1, wherein said second membrane intercepts less than 50 percent of the electrons reaching it.

5. The apparatus set forth in claim 4, wherein said second membrane intercepts less than 30 percent of the electrons reaching it.

6. The apparatus set forth in claim 1, wherein said second membrane comprises an openwork structure of which the solid parts are substantially impermeable to the electrons which are generated in said apparatus and in which the solid parts represent not more than 20 percent of the cross section of said second membrane.

7. The apparatus set forth in claim 1, wherein said second membrane comprises an openwork structure of which the solid parts are at least partially permeable to the electrons generated in said apparatus and in which the solid parts represent between 40 percent and 60 percent of the cross section of said second membrane.

8. The apparatus set forth in claim 7, wherein the total mass thickness of said first membrane, the gas between the membranes, and said solid parts of said second membrane is less than half the range of the electrons generated in said apparatus.

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