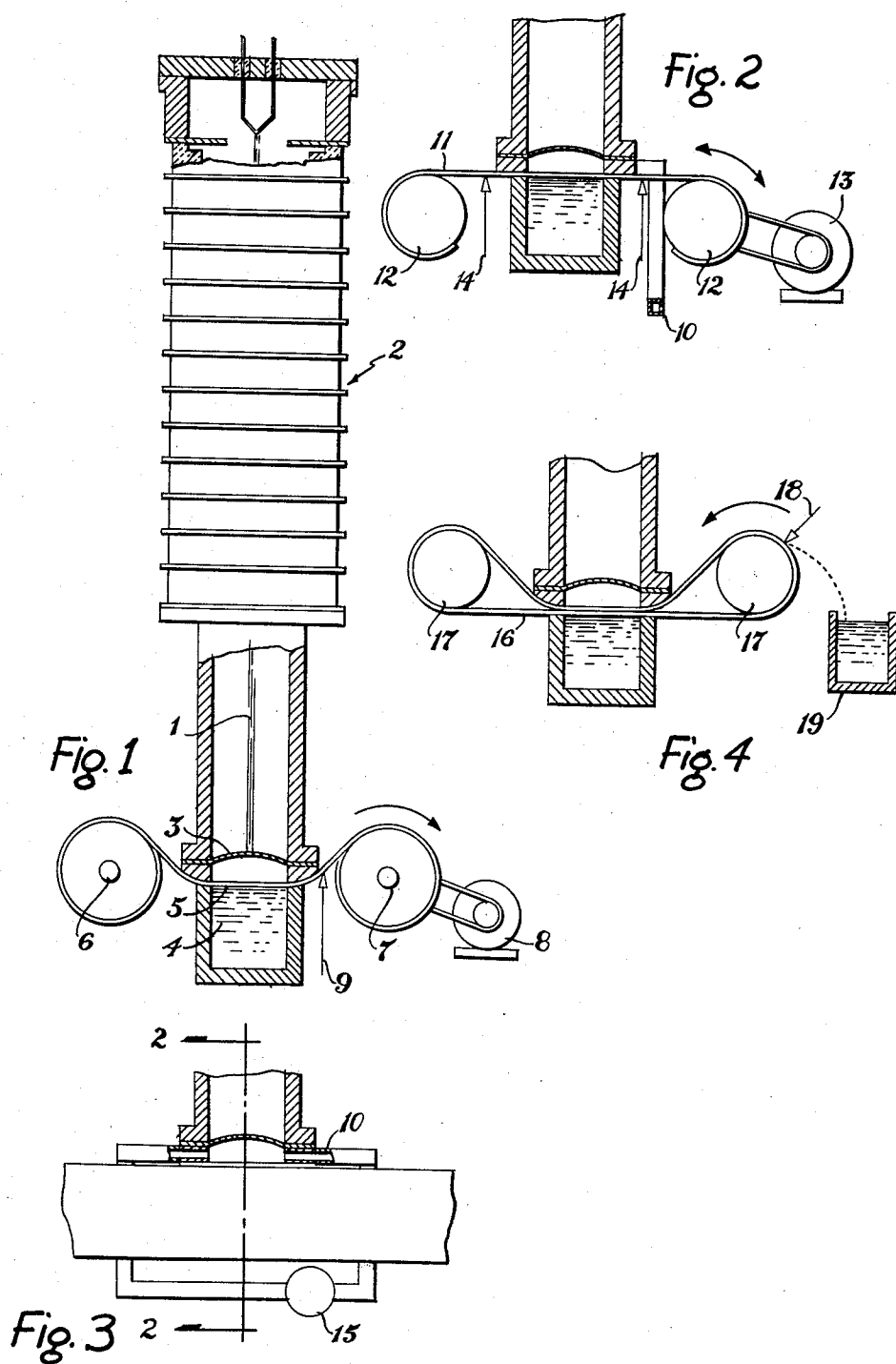


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ELECTRON IRRADIATION

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ELECTRON IRRADIATION

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This invention relates to irradiation by high energy electrons and in particular to a method of and apparatus for irradiating materials which tend to coagulate or degenerate or to cause corrosion at the electron window. The invention is particularly useful in the irradiation of fluids, such as liquids, gases or finely divided solids, which come in contact with the electron window during the irradiation process. However, the invention is equally useful in the irradiation of liquids and solid materials which under electron bombardment may boil or sublime so as to create a vapor phase which is in contact with the electron window even though the major portion of the material irradiated is spaced from the window.

High-energy electron beams are being increasingly used for the irradiation of various materials in radiation chemistry and in the sterilization or preservation of food and drugs. The beam of electrons is commonly produced by accelerating electrons to high energy in an evacuated region. After being accelerated to the required energy, the electrons emerge from the evacuated region through an electron window comprising a thin metal foil and are directed onto the product to be irradiated. Since a certain amount of energy is lost due to scattering in the air intervening between the electron window and the product, the product is placed as close to the window as possible; consequently, liquid products may actually be in contact with the window. However, owing to the chemical changes produced in the liquid by electron bombardment, and owing to the relatively slow rate of flow at the window due to the viscosity of the liquid, such liquid materials tend to coagulate or degenerate at the electron window so as to form a scum or other objectionable formation at the window. One of the principal difficulties introduced by such objectionable formations on the electron window is the fact that it absorbs energy from electron beam, thereby not only reducing efficiency but also increasing the danger that the electron window will break down due to overheating.

In accordance with the invention, this undesirable aspect of electron irradiation of liquids is avoided by shielding the electron window from the liquid with a second electron-permeable membrane which may be moved so as to remove from the path of the electron beam the accumulated deposits thus formed on the surface of the membrane. In one embodiment of the invention, this additional electron-permeable membrane takes the form of an extended length of thin material, such as plastic film or metal foil, which is fed through the electron beam and is then disposed of. In another embodiment of the invention a relatively short length of such plastic film or metal foil is moved through the electron beam repeatedly. In any event, if, despite the motion of the membrane, deposits are accumulated on its surface, such deposits may be removed between passages through the electron beam.

The invention is useful not only in the irradiation of

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liquids which may deposit solids on the electron window, but also in the irradiation of gases which may polymerize or combine to produce solid or viscous deposits on the window. Moreover, an intervening sheet constructed in accordance with the invention will keep away chemically active gases which might attack the window especially when such gases are excited and ionized as would be the case under electron bombardment. While irradiation of a liquid medium presents a more serious problem because formation of solid deposits is almost certain to occur, similar deposition of material is to be expected from gaseous materials or it may be caused by projection upward of condensable vapors or of particles from the object being irradiated which object may itself be a liquid or a solid medium. An intervening sheet constructed in accordance with the invention is equally effective in all of these cases and likewise may afford some protection to the window against the kinetic effect of flying material by serving as a mechanical barrier.

Corrosion is now a recognized window problem, and it is evident that it will also be a problem on the screen or intervening sheet. Even if the screen does not get covered with a thick film of deposit (which would increase energy absorption and retard cooling and lead to burnout), it will corrode unless of very resistant material. All these problems are solved, in accordance with the invention, by motion of the screen, especially progressive motion on a short endless belt or from one roll to another.

Most gases are corrosive, and so the invention will generally be useful in the irradiation of gases. For example, during irradiation even the nitrogen in air is converted to nitrous oxide, which is highly corrosive. If in addition to the corrosive action the gas polymerizes, it will coat the window and spoil the cooling action. Even in the irradiation of liquids, the problems associated with the irradiation of gases may arise since there will probably be much boiling, so that even if the liquid is spaced from the window at least the vapor phase will come in contact with the window during irradiation.

The invention comprehends in essence an electron-permeable sheet or screen outside the regular electron window of an electron accelerator; this screen is gas tight, though not necessarily vacuum tight, and is moved during the irradiation process. In one embodiment of the invention the moving window is scraped to remove deposits, but the invention is not limited to this scraping action. In general there will be gas on both sides of the screen. For example, helium or some other non-corrosive gas may be used in the space between the regular electron window and the screen. The invention is particularly useful at high powers or at relatively low voltages, since each is accompanied by relatively large energy absorption in the electron window; moreover, at high powers the product irradiated reacts more violently, while at low voltages the product must be nearer the window. The invention is also particularly useful where the absorber, or product irradiated, is either a liquid, which tends to form deposits, or else a gas or any other corrosive medium.

The screen in conjunction with the regular electron window provides a duct through which a gas may be passed at considerable velocity so as to secure really effective cooling of both window and sheet. This gas may pass through the duct either lengthwise or transversely and might be of some inert gas such as helium or nitrogen, though the latter is probably reasonably active chemically when ionized. If helium is used the duct could form part of a closed cooling system so as to conserve this expensive gas.

The invention may best be understood from the fol-

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lowing detailed description thereof having reference to the accompanying drawing in which:

Fig. 1 is a diagrammatic view in longitudinal central section through an electron acceleration tube whose window is protected in accordance with the invention;

Fig. 2 is a view along the line 2—2 of Fig. 3 and is a view similar to that of Fig. 1 showing a modified form of the invention.

Fig. 3 is a view of the apparatus of Fig. 2 taken at right angles thereto; and

Fig. 4 is a view similar to that of Fig. 1 showing another modified form of the invention.

Referring to the drawing and first to Fig. 1 thereof, an electron beam 1 is accelerated to high energy within an evacuated electron acceleration tube 2 by any conventional electron-accelerating means, such as an electrostatic accelerator, a resonance transformer or a microwave linear accelerator. The electron beam 1 may be of circular cross section or may be extended in a plane parallel to that of the drawing. The acceleration tube 2 terminates in an electron window 3 integral with the acceleration tube 2. The electron window 3 may comprise, for example, a thin sheet of aluminum foil and may be concave upwards slightly, as shown, so as to provide greater mechanical strength in supporting atmospheric pressure. The liquid product 4 which is to be irradiated is conveyed through the beam 1 in any conventional manner. In accordance with the invention, a thin sheet 5 of aluminum or other suitable metal or plastic separates the liquid 4 from the electron window 3, so that the product 4 never makes contact with the window 3. The sheet 5 is shown in Fig. 1 as being formed into a roll which is supported on a spindle 6 and the leading edge travels past the electron window 3 and on to a take up spindle 7. The material is wound onto the take up spindle 7 either continuously or intermittently by means of a suitable motor 8. If the sheet is of dispensible material, it may simply be wound up until the roll on the spindle 6 is exhausted and then the used roll may be disposed of and a new roll substituted. Alternatively the same roll of material may be used repeatedly either by reversing the motion of the material for alternate runs or by taking the full wound roll from the take up spindle 7 and replacing onto the supply spindle 6. If despite the motion of the material deposits are accumulated on the surface of sheet 5, these deposits may be removed by a scraper 9 which removes the deposits as the sheet 5 leaves the vicinity of the electron window 3. Owing to the concavity of the electron window 3, there is a space between the sheet 5 and the window 3 which constitutes a duct suitable for receiving an air cooling blast from a jet discharge device 10 (Fig. 3). The screen may rub lightly over the metal surfaces so as to make a reasonably gas-tight contact where required. It need not be absolutely gas-tight and certainly need not be vacuum-tight. Aluminum would be an ideal sheet material.

Referring now to Fig. 2, the electron window 3 may be shielded by a short length of thin metallic or plastic sheet 11 which is given an oscillating motion by any suitable mechanism. In Fig. 2 the sheet 11 is supported by and affixed to a pair of rollers 12 which are given an oscillating motion by means of a suitable motor 13. If despite the motion of the sheet 5 material is deposited thereon, such material may be removed by means of a pair of scrapers 14 positioned so as to remove the material so deposited when the sheet 11 leaves the vicinity of the electron window 3. The amplitude of the oscillating motion must, of course, be sufficient to allow for the cleaning operation. It is to be understood that the scope of the invention is not limited to the use of scrapers for cleaning the sheet but includes any suitable alternative cleaning method, such as running the sheet 11 through an appropriate chemical bath.

In the apparatus of Figs. 2 and 3, as in the apparatus of Fig. 1, the duct between the window 3 and the sheet

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5 or 11 may be used for cooling by directing therethrough a blast of air, of nitrogen, or of some other suitable gas. Nitrogen, of course, would be preferable in case of fire hazard. Helium would be an ideal coolant and, in order to preserve this expensive gas, it might be continuously recirculated through the jet discharge device 10 by means of a suitable compressor 15.

Referring now to Fig. 4, therein is shown an endless belt 16 of thin metallic or plastic sheet material which travels around a suitable array of pulleys 17 and from which any objectionable material is removed by the scraper 18 which is arranged to remove coagulated material. It may be that the material which is deposited on the moveable sheet 16 is not always an objectionable waste even though it is always objectionable. It may be very useful and its recovery be important as well as necessary. A suitable receptacle 19 may therefore be provided for recovery of these deposits. In the embodiment of the invention shown in Fig. 4, it will be observed that that there are two thicknesses of the sheet 16 which are in the path of the electron beam 1.

Having thus described the method of the invention, together with several illustrative embodiments of apparatus for carrying out the method, it is to be understood that, although specific terms are employed, they are used in a generic and descriptive sense and not for purposes of limitation, the scope of the invention being set forth in the following claims.

I claim:

1. The method of irradiating with artificially accelerated electrons matter which tends to coagulate or degenerate or to cause corrosion at the electron window which method comprises: producing a beam of high-energy electrons in vacuo, directing said beam out of said vacuum through an electron window and thence directing said beam onto said matter through a solid electron-permeable sheet which covers said electron window, and imparting translational motion to said sheet along its own plane such that the accumulated deposits formed on the surface of the sheet are removed from the path of the electron beam.

2. The method of irradiating with artificially accelerated electrons matter which tends to coagulate or degenerate or to cause corrosion at the electron window which method comprises: producing a beam of high-energy electrons in vacuo, directing said beam out of said vacuum through an electron window and thence directing said beam onto said matter through a solid electron-permeable sheet which covers said electron window, moving said sheet out of the path of said electron beam, and removing accumulated deposits from the surface of said sheet while the same is out of the path of said electron beam.

3. The method of irradiating with artificially accelerated electrons matter which tends to coagulate or degenerate or to cause corrosion at the electron window which method comprises: producing a beam of high-energy electrons in vacuo, directing said beam out of said vacuum through an electron window and thence directing said beam onto said matter through a solid electron-permeable sheet which covers said electron window, repeatedly moving said sheet through the path of said electron beam, and removing accumulated deposits from the surface of said sheet between passages through the path of said electron beam.

4. Apparatus for electron irradiation of matter which tends to coagulate or degenerate or to cause corrosion at the electron window, comprising in combination: an evacuated acceleration tube terminating in an electron window, means for producing an electron beam within said tube and directing said beam out of said tube through said window, a solid electron-permeable sheet of extended area supported so that a portion thereof covers said window, and means for moving said sheet through said electron beam.

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5. Apparatus in accordance with claim 4, wherein means is provided for discharging a coolant gas between said window and said sheet, whereby said apparatus is enabled to transmit larger amounts of output electron power.

6. Apparatus for electron irradiation of matter which tends to coagulate or degenerate or to cause corrosion at the electron window, comprising in combination: an evacuated acceleration tube terminating in an electron window, means for producing an electron beam within said tube and directing said beam out of said tube through said window, a solid electron-permeable sheet of extended area supported so that a portion thereof covers said window, means for repeatedly moving said sheet through said electron beam, and means for removing from said sheet, while it is out of the path of said electron beam, material accumulated thereon.

7. Apparatus for electron irradiation of matter under conditions which tend to result in coagulation or degeneration of matter, or in corrosion, at the electron window, comprising in combination: an evacuated acceleration tube terminating in an electron window, means for producing an electron beam within said tube and directing

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said beam out of said tube through said window, a solid electron-permeable sheet of extended area supported so as to form in cooperation with said window a gas-tight compartment therebetween, whereby a portion of said sheet covers said window, and means for moving said sheet through said electron beam.

8. Apparatus in accordance with claim 7, wherein said gas-tight compartment forms a duct and wherein means is provided for discharging a coolant gas through said duct, whereby said apparatus is enabled to transmit larger amounts of output electron power.

9. A method in accordance with claim 1, wherein said translational motion is imparted to said sheet intermittently.

10. Apparatus in accordance with claim 7, wherein said gas-tight compartment contains an inert gas.

11. Apparatus in accordance with claim 7, wherein said gas-tight compartment contains helium.

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