

United States Patent

Coleman

[15] 3,654,459

[45] Apr. 4, 1972

[54] CONTROLLED ATMOSPHERE CHAMBER FOR TREATING PRODUCTS WITH IONIZING RADIATION

2,887,584 5/1959 Nygard 250/49.5 TE
3,217,135 11/1965 Eklund.....250/49.5 TE
3,433,949 3/1969 Truhan.....250/51

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[21] Appl. No.: 850,927

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313/74
[51] Int. Cl. H01j 37/30
[58] Field of Search 118/49.1, 49.5, 620;
219/121 EB; 313/74; 250/49.5 R, 49.5 TE, 51, 52

[56] References Cited

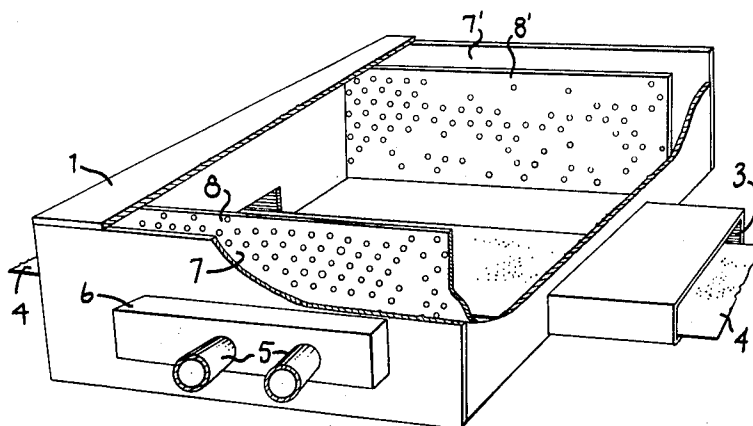
UNITED STATES PATENTS

2,816,231 12/1957 Nygard 313/74 X

[57] ABSTRACT

Apparatus which permits treatment of products with ionizing radiation in a controlled atmosphere comprises a chamber having inlet and outlet openings for the passage of a product to be treated, a radiation-permeable window in one surface, and at least one gas reservoir within the chamber separated by a foraminous panel. Gas is introduced into the reservoir, passes through the foraminous panel and over and around the path of travel of the workpiece to be treated.

16 Claims, 4 Drawing Figures



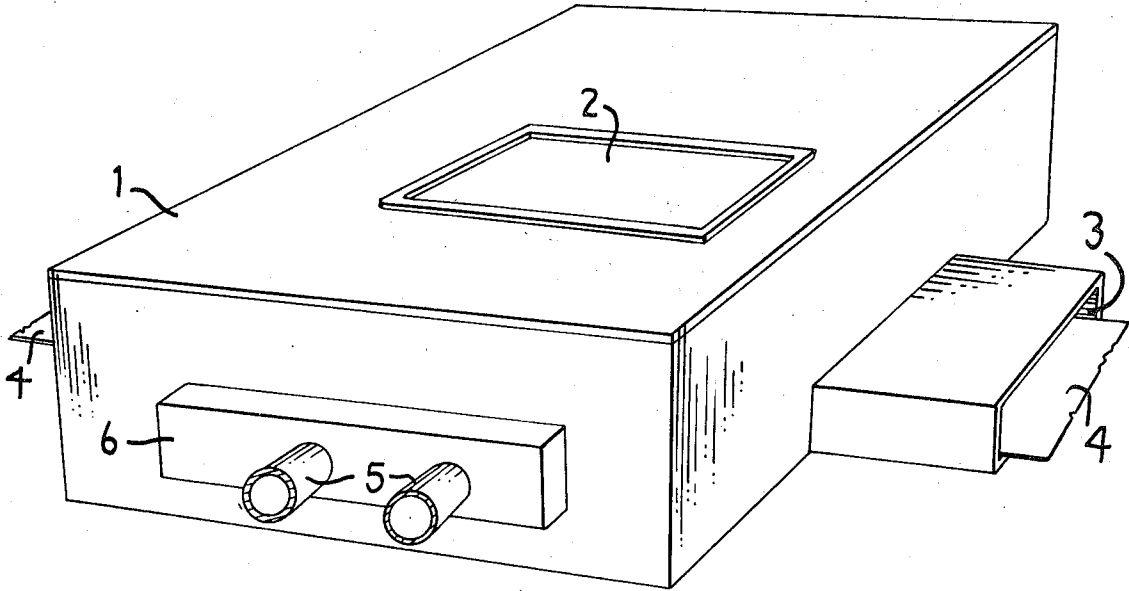


FIG. 1

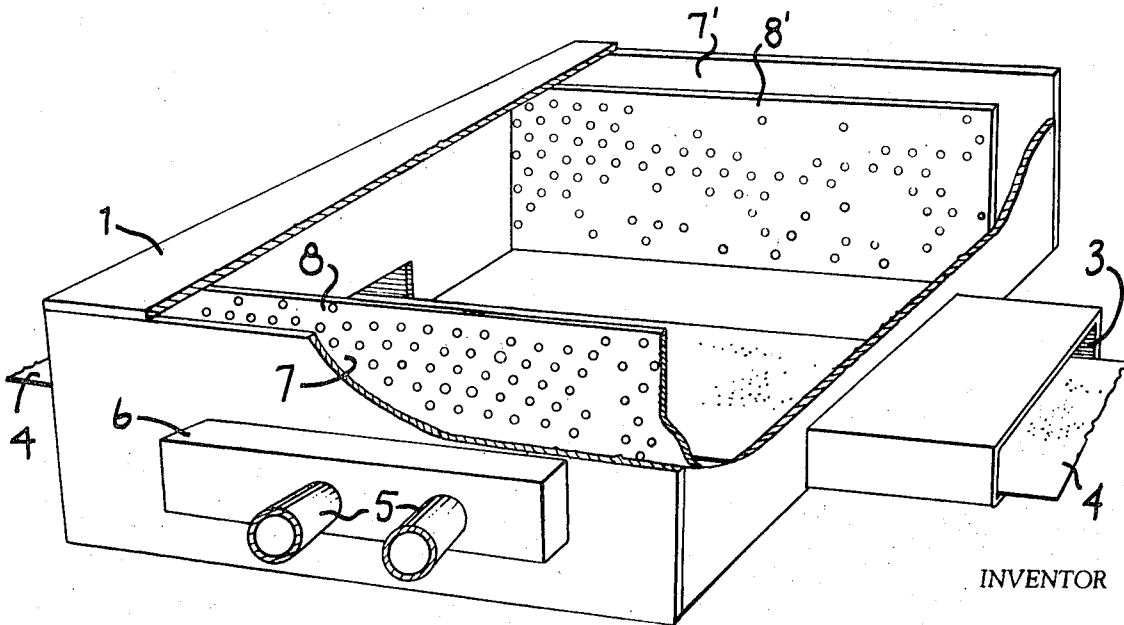


FIG. 2

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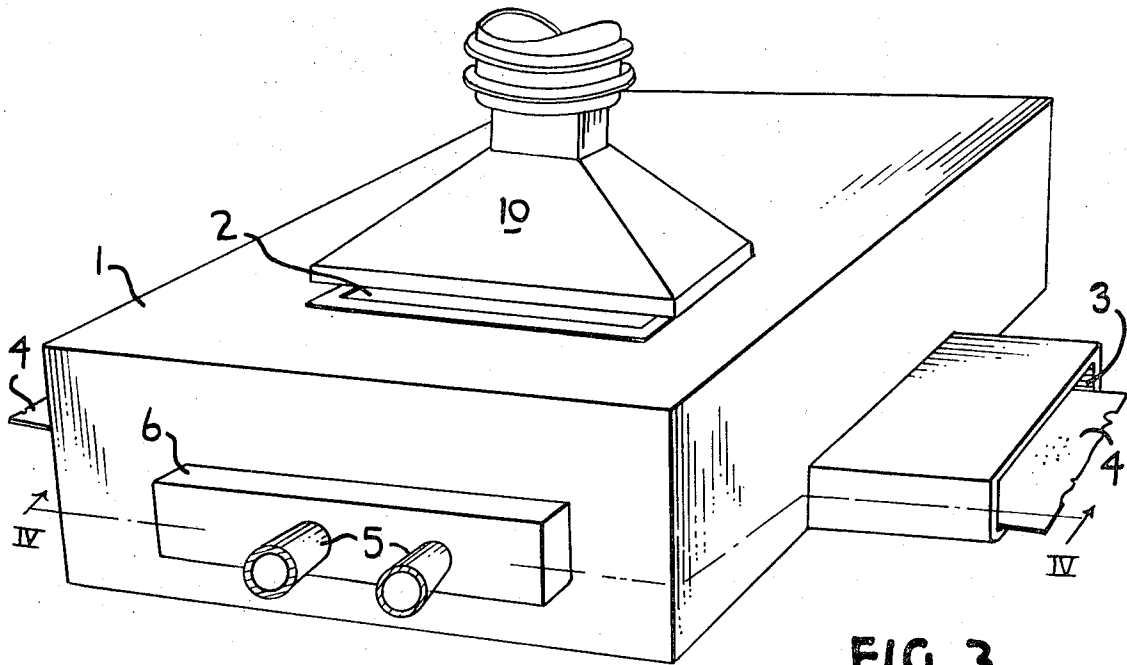


FIG. 3

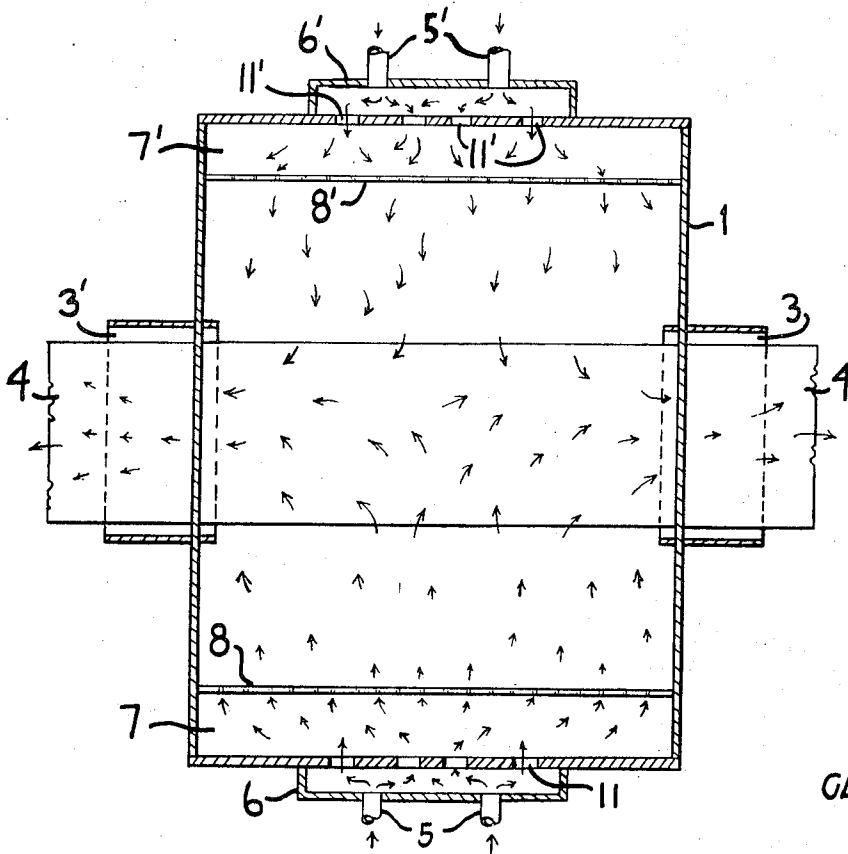


FIG. 4

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CONTROLLED ATMOSPHERE CHAMBER FOR TREATING PRODUCTS WITH IONIZING RADIATION

BACKGROUND OF THE INVENTION

Processes in which materials are irradiated to effect curing, sterilization, etc., are known in the art and are becoming of increasing importance. The use of irradiation for the curing of coatings, for instance, has been found to provide numerous advantages, and an irradiation step is now utilized in a number of coating processes.

Processes involving irradiation are carried out by treating radiation-sensitive materials with high energy radiation and/or the secondary energies resulting from conversion of electrons or other particle energy to X-rays or gamma radiation. While various types of radiation are suitable for this purpose, radiation produced by accelerated high energy electrons has been found to be most economically applicable and to provide generally the most satisfactory results.

Various types of equipment are known to produce radiation, including resonance-type accelerators, electron linacs, Van de Graaff generators, betatrons, synchrotrons, cyclotrons, atomic piles, and others.

Used in commercial irradiation processes are accelerators operating at energy levels as low as 50,000 electron volts or lower and as high as 10 million electron volts or higher. For example, high power electron linear accelerators, such as the ARCO type traveling wave accelerator, Model Mark I, operate at 3 to 10 million electron volts, while commonly used DC type accelerators operate at 100,000 to 4 million electron volts. Such accelerators provide a beam of electrons which can be directed to a given area as desired and thus to the product to be irradiated. Several such accelerators are described in U.S. Pat. No. 2,763,609 and British Pat. No. 762,953.

It has been found that the efficiency of irradiation processes in many cases depends upon the environment of the material being irradiated. For example, many materials are more or less radiation-sensitive, depending upon the atmosphere in which they are treated. The presence of certain levels of oxygen in the atmosphere is often a determining factor in both the rate of the desired reaction and the quality of the finished irradiated product. Other factors involve hazards such as the possibility of fire or explosion and the production of ozone during the irradiation process.

It is therefore recognized that it is desirable to carry out irradiation processes in a controlled atmosphere in which the level of oxygen can be maintained within desired limits. While this is relatively easily carried out in a closed system, most processes cannot be economically performed in closed apparatus and heretofore it has not been possible to provide efficient control of the atmosphere surrounding a workpiece in a process wherein the products treated are continuously or intermittently moving.

One proposal for providing an inert atmosphere during irradiation is described in U.S. Pat. No. 2,887,584. The apparatus as described therein comprises a chamber open at the bottom into which the product to be irradiated is passed while attempting to maintain a relatively inert atmosphere inside the chamber by use of a lighter-than-air inert gas to displace the air therein. The apparatus as described in the said patent is quite limited in the extent to which oxygen can be excluded from the path of the product to be irradiated, and for this reason does not appear to have been successfully utilized.

SUMMARY OF THE INVENTION

The apparatus of the present invention comprises a chamber having:

- A. spaced outer walls with inlet and outlet openings establishing a path of travel for the workpiece to be treated;
- B. a radiation-permeable window in a surface of the chamber, the window being positioned over at least a portion of the path of travel of the workpiece;

C. at least one foraminous panel within the chamber defining a reservoir between the panel and an outer wall of the chamber; and

D. means for introducing gas into the reservoir.

The above-described apparatus provides for treating products with ionizing radiation in an atmosphere in which the level of oxygen or any other gaseous component can be controlled within quite rigid limits. For example, where it is desired to exclude oxygen to the extent possible, the present apparatus can easily attain oxygen levels in the path of travel of a workpiece as low as 100 parts per million or even lower, even where products are being continuously irradiated and thus are continuously moving through the apparatus.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a perspective view of an apparatus comprising one embodiment of the invention.

FIG. 2 is a cutaway view of the apparatus of FIG. 1 showing the interior of the chamber.

FIG. 3 is a perspective view showing the relationship of the apparatus in conjunction with the lower portion of an electron beam accelerator during use.

FIG. 4 is a sectional view of the apparatus along line IV—IV of FIG. 3.

Referring to FIG. 1, the chamber 1 has in the top surface thereof a radiation-permeable window 2 and an opening 3 through which there is passing a product 4. Gas inlets 5 introduce gas into a manifold 6 from a gas source (not shown).

In FIG. 2, the chamber 1 contains within it reservoirs 7 and 7' formed by foraminous panels 8 and 8'. The product 4 is passing through opening 3.

In FIG. 3, the apparatus comprising the chamber 1 having therein a window 2 is shown in combination with an electron beam accelerator 10, whereby during operation radiation from the accelerator passes through the window 2 onto the product 4.

In FIG. 4, arrows show the distribution of gas throughout the apparatus. Gas enters the reservoirs 7 and 7' from gas inlets 5 and 5' and manifolds 6 and 6' through openings 11 and 11'. From the reservoirs 7 and 7' the gas is distributed through foraminous panels 8 and 8' and surrounds the product 4, eventually passing out through inlet and outlet openings 3 and 3'.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The apparatus can be of any suitable size or shape depending upon the nature of the product or workpiece to be treated.

It is ordinarily rectangular in shape with the radiation-permeable window in the upper surface, such windows being well known in the art and being formed of a material which substantially excludes the passage of gases, but which permits radiation to pass therethrough. Generally, such windows are made of a section of a material having a low atomic number, such as aluminum or beryllium, and are usually quite thin, having, for example, a weight of from about 3 to about 10 milligrams per square centimeter. The common aluminum foil of commerce is satisfactory for use as the window. The dimensions of the window and its position in the surface of the chamber are not critical, depending upon factors such as the area scanned by the electron beam, the dimensions of the workpiece, etc., so long as it is positioned so that radiation passing through the window impinges on the desired portion of the path of travel of the product being irradiated.

The radiation-permeable window in the chamber can be a common window with the window of the accelerator or other radiation source through which the radiation is emitted. Such an arrangement has the advantage of eliminating one window and thus reduces the loss of radiation occasioned thereby, but also makes the apparatus less flexible and more expensive to repair or replace.

Within the chamber are one or more foraminous panels defining a reservoir between an outer wall of the chamber and

the panels. These panels can be of varying size and shape, although preferably rectangular to conform to the cross-section of the chamber. It is preferred that the foraminous panels be oppositely spaced and positioned on each side of the path of travel of the product. The holes in the panels should be distributed more or less uniformly over their surface and should be sufficient in size and number to provide a steady and relatively uniform diffusion of gas into the area of the product.

The volume of the reservoirs is relatively unimportant, except that each reservoir should be sufficient in volume so as to reduce turbulence from the introduction of gas and to provide a cushioning effect to any gas flow from the gas inlet. The optimum volume of the reservoirs thus depends upon the number and type of gas inlets, the flow rate of gas, and the overall dimensions of the components of the apparatus. In normal operation each reservoir acts as a plenum and is at a higher pressure than the interior of the chamber, thereby maintaining relatively uniform flow through each of the holes in the foraminous panels.

The chamber has openings establishing the path of travel for the product. Ordinarily, these openings are in oppositely spaced outer walls of the chamber and the path of travel passes through the chamber, between the foraminous panels, and beneath the window and the path of the radiation. The cross-sectional area of these inlet and outlet openings should be as low as possible to permit the passage of the product, and the larger the area of the inlet and outlet, the longer the path of travel through the chamber should be. The object is to provide a stable condition inside the chamber, thereby minimizing differences due to external changes in atmosphere, such as caused by air movements.

It is desirable to provide outwardly extending sections from the outer walls of the chamber and to locate the inlet and outlet openings in these extended sections. The extensions are generally of substantially the same cross-section as the openings and should extend outwardly for a length sufficient to provide laminar flow of the exit gases from the chamber. The size and shape of the inlet and outlet openings, and the outwardly extending sections, can be made to conform to the size and shape of various workpieces. Replaceable or movable sections having different configurations can be provided if desired.

The apparatus also comprises means for the introduction of gas into the reservoir or reservoirs. In order to assist in providing a non-turbulent atmosphere, this is usually accomplished by providing a gas inlet into a manifold, from which the gas passes into the reservoir through a plurality of openings. The gas inlets are usually spaced so as to avoid direct flow from them into the openings.

As indicated, the overall size of the apparatus can be varied, although it can be noted that the overall distance the radiation must travel before meeting the surface of the workpiece affects the distribution of energy in the product treated. The apparatus can be constructed of any material which is not overly sensitive to radiation, i.e., which does not substantially degrade and become unusable when subjected to the type of radiation employed. Most metals, glass, etc., can be used. It is preferred that a noncorrosive material be utilized and stainless steel is the specifically preferred material of construction, except for the radiation-permeable window, which is preferably aluminum.

The apparatus can also be provided with certain optional components. Means for conveying the product along the path of travel can be included, these being, for example, rollers located in the lower portion of the chamber; these can be power-driven if desired. It is also desirable to include cooling means in the area of the chamber upon which the radiation impinges when not entirely absorbed by any material being irradiated. Tubes or coils along the bottom of the chamber through which a coolant fluid can be circulated comprise one type of cooling means; other types can be a block of heat-conducting material, a water or other reservoir, or any other means which provides absorption and/or transfer of heat.

Other auxiliary equipment which is often desirable include means for introducing gas at the inlet and outlet; these can be gas distribution tubes extending along the opening and having a plurality of inlet holes spaced along their length with the gas flow directed downward, preferably at a 45° angle. Still other optional features include provision for continuously or periodically analyzing the atmosphere inside the chamber, means for viewing the interior of the chamber and the product, such as cameras, etc., vacuum or other pumps, and the like.

The apparatus can be varied in structure to meet the needs of specific processes in which it is employed. For example, the apparatus can be used with more than one source of radiation by providing a plurality of radiation-permeable windows as required. For example, both sides of a workpiece can be irradiated, or a workpiece of complex shape can be irradiated from various angles.

In one embodiment of the invention, an apparatus as shown in the drawings comprises a chamber 20 inches long, 20 inches wide and 3½ inches deep, having in the top surface a radiation-permeable window, made of aluminum foil (0.7 mil thick), 5 inches wide and 10 inches long. Two foraminous panels having 0.010 inch diameter holes uniformly spaced three-eighths inch apart over their entire surface extend along the length of the chamber, one on each side, spaced 2 inches from the outer wall. Each of the inlet and outlet openings in the chamber is 16 inches wide by three-fourths inch high, and each is located in a section of the chamber extending outwardly 11 inches from opposite chamber walls; the path of travel of the product is thus 42 inches long and is aligned under the radiation-permeable window. A manifold having four openings each three-fourths inch in diameter opens into each of the reservoirs behind the foraminous panels, each manifold being connected to a source of nitrogen.

The apparatus as described is constructed of stainless steel and can accommodate products up to about 14 inches wide and about one-fourth inch thick.

In operation of the above-described apparatus, a total nitrogen flow of 40 cubic feet per minute is passed into the manifold, distributed into the reservoirs, and passed through the foraminous panels into the path of travel of the product. A product line 9¼ inches wide is carried through the chamber at a rate of 200 feet per minute. During such operation, the concentration of oxygen in the path of travel of the product is less than 100 parts per million. If the inlet and outlet openings are increased, a product line 14 inches in width can be carried through the chamber at 200 feet per minute with the oxygen content still maintained below 200 parts per million.

The apparatus can also be used to provide a sustained level of oxygen (other gas) during operation. This is desirable using some coating materials, for example, and is accomplished by feeding a controlled mixture of oxygen and nitrogen through the gas distribution system. An advantage of the use of the apparatus in this manner is that ozone and other gaseous by-products are removed during operation and thus the concentration of such by-products does not build up to undesirably high levels. The apparatus can also be operated at reduced pressure, by providing suitable auxiliary equipment, e.g. pumps, chambers, etc.

According to the provisions of the patent statutes, there are described above the invention and what are now considered to be its best embodiments. However, within the scope of the appended claims, it is to be understood that the invention can be practiced otherwise than as specifically described.

I claim:

1. Apparatus for treating products with ionizing radiation in a controlled atmosphere, said apparatus comprising a substantially enclosed chamber having

- A. spaced outer walls with spaced inlet and outlet openings establishing a path of travel for a workpiece;
- B. a radiation-permeable window in a surface of said chamber, said window being formed of a material which excludes the passage of gases and being positioned over at least a portion of said path of travel;

- C. at least one foraminous panel within said chamber defining a reservoir between the panel and an outer wall of the chamber; and
- D. means for introducing gas into said reservoir and through said foraminous panel into said path of travel.
2. The apparatus of claim 1 in which said inlet and outlet openings are located in outwardly extending sections of said outer walls.
3. The apparatus of claim 1 in which said foraminous panel has substantially uniform openings spaced over its entire surface.
4. The apparatus of claim 1 in which said means for introducing gas comprises a plurality of gas inlet openings into said reservoir.
5. The apparatus of claim 1 in which said radiation-permeable window is a thin metal section.
6. The apparatus of claim 5 in which said metal is aluminum.
7. Apparatus for treating products with ionizing radiation in a controlled atmosphere, said apparatus comprising a substantially enclosed chamber having
- A. oppositely spaced outer walls with spaced inlet and outlet openings establishing a path of travel for a workpiece;
- B. a radiation-permeable window in a surface of said chamber, said window being formed of a material which excludes the passage of gases and being positioned over at least a portion of said path of travel;
- C. oppositely spaced foraminous panels along each side of said path of travel, each of said panels defining a reservoir between the panel and an outer wall of the chamber; and
- D. means for introducing gas into said reservoirs and through said foraminous panels into said path of travel.
8. The apparatus of claim 7 in which said inlet and outlet openings are located in outwardly extending sections of said outer walls.
9. The apparatus of claim 7 in which said foraminous panels have substantially uniform openings spaced over their entire surfaces.
10. The apparatus of claim 7 in which said means for introducing gas comprises a plurality of gas inlet openings into each of said reservoirs.
11. The apparatus of claim 7 in which said radiation-permeable window is a thin metal section.
12. Apparatus for treating products with ionizing radiation in a controlled atmosphere, said apparatus comprising a substantially enclosed chamber having
- A. spaced outer walls with spaced inlet and outlet openings establishing a path of travel for a workpiece;
- B. a radiation-permeable window in a surface of said chamber, said window being formed of a material which excludes the passage of gases and being positioned over at least a portion of said path of travel;
- C. at least one foraminous panel within said chamber defining a reservoir between the panel and an outer wall of said chamber;
- D. means for introducing gas into said reservoir and through said foraminous panel into said path of travel; and
- E. means for passing ionizing radiation through said radiation-permeable window into said path of travel.
13. The apparatus of claim 12 in which said means for passing ionizing radiation is an electron beam accelerator.
14. The apparatus of claim 13 in which said accelerator comprises a radiation-permeable window which is a common window with the radiation-permeable window in said chamber.
15. The apparatus of claim 13 in which said accelerator is an electron linear accelerator operating between about 3 million and about 10 million electron volts.
16. The apparatus of claim 13 in which said accelerator is a DC accelerator operating between about 100,000 and about 4 million electron volts.

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