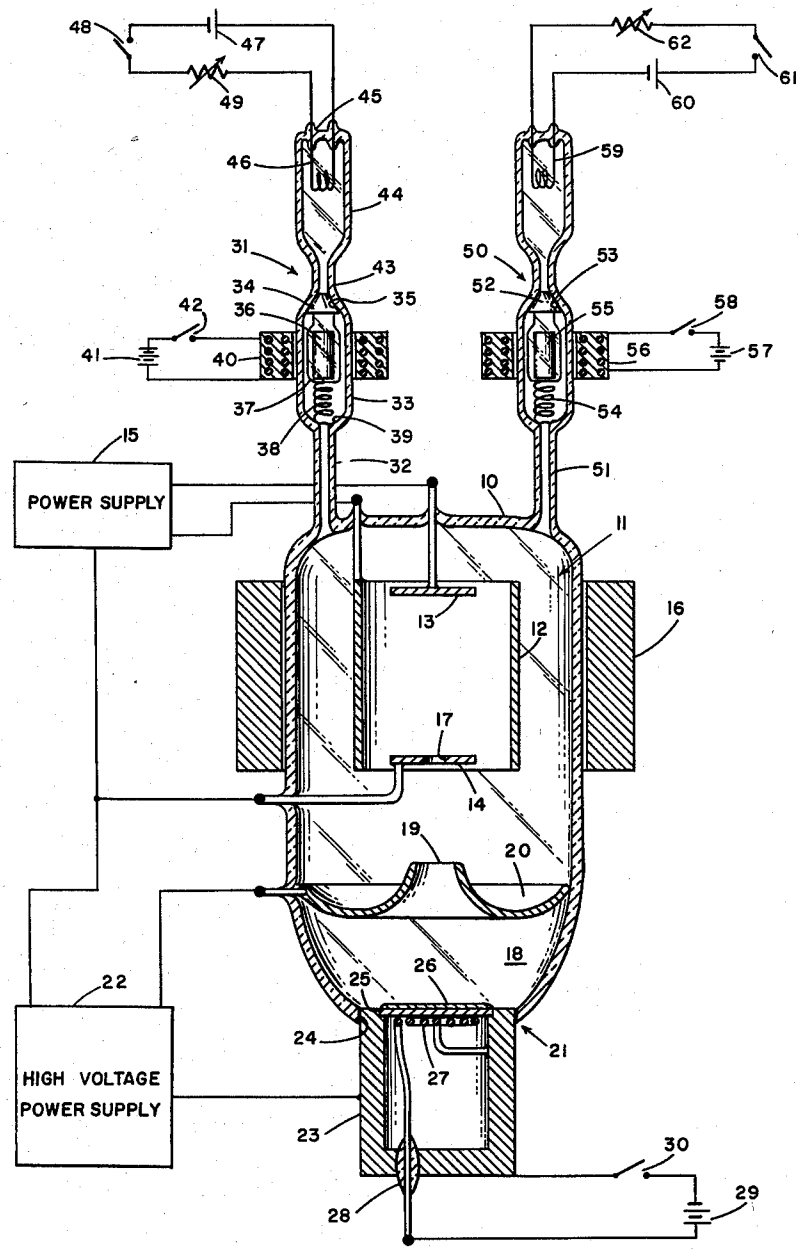
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METHOD AND APPARATUS FOR RENEWING TARGETS

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METHOD AND APPARATUS FOR RENEWING TARGETS

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This invention relates to methods and apparatus for renewing targets and, more particularly, pertains to new and improved methods and apparatus for conditioning a target element of a particle accelerator with a selected gas.

The methods and apparatus for renewing targets embodying the present invention may have utility in a variety of applications. However, it is ideally suited for use in association with a particle accelerator intended for the generation of neutrons through reactions between highly accelerated deuterium ions and a target material, such as tritium. For convenience, the present invention will be described in this connection.

Experience with neutron generators of the foregoing type has indicated that the neutron yield may not always be maintained at a desired high level because of depletion of tritium in the target. Consequently, the target must be replaced frequently.

To replace the target, the accelerator must first be disassembled and the depleted target removed. A new target is prepared, according to present techniques, by hydriding a layer of zirconium metal mounted on a tungsten backing with deuterium or tritium, as the case may be. The accelerator is then reassembled with the new target; however, in this last step of the process it is not possible to heat the device above approximately 400° C. without undue loss of the valuable isotope of hydrogen. This severely limits the efficiency of the out-gassing process and the operation of the accelerator may be impaired by undesirable contaminants.

Furthermore, experience has indicated that targets which have been exposed to the atmosphere after hydriding often develop a non-hydrided surface layer (presumably due to oxidation). This surface layer may be of the order of 20,000 to 30,000 electron volts thick for deuterons of 100 kilovolts energy. Accordingly, it is necessary to accelerate the deuterons through 120 to 130 kilovolts in order to obtain a resultant energy of 100 kilovolts (at which maximum neutron yield occurs) for bombardment of the underlying hydride layer after the deuterons have penetrated the surface layer. In many applications of the accelerator, this additional voltage may not be readily attainable.

It is, therefore, an object of the present invention to provide new and improved methods and apparatus for renewing such targets without disassembling the accelerator.

Another object of the present invention is to provide new and improved methods and apparatus for hydriding the target of an accelerator in situ either in an initial step of an assembly process or as a step in the process of renewing the hydride layer as may be required at any subsequent time.

A method embodying the present invention may be employed to treat a gas-absorbent element of a particle accelerator provided with an envelope. The method comprises the steps of introducing a selected gas into the envelope of the particle accelerator and increasing the

temperature of the gas-absorbent element to a value at which the selected gas may be absorbed. Thereafter, the temperature of the gas-absorbent element is reduced below the aforesaid value and excess gas is removed from the envelope.

According to another aspect of the present invention, there is provided apparatus for carrying out the above-described method. This apparatus may be employed in combination with an element of a particle accelerator having an envelope and comprises a gas-storing mechanism in communication with the envelope. The gas-storing mechanism has gas-emitting and gas-absorbing operating conditions. The apparatus further comprises control means for selectively establishing the gas-emitting operating condition in the mechanism to introduce gas into the envelope and means are provided for conditioning the element to absorb gas. The control means may also be employed for selectively establishing the gas-absorbing operating condition so as to absorb excess gas from the envelope.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which the single figure is a view in longitudinal cross section of a particle accelerator equipped to carry out the method embodying the present invention and illustrating novel apparatus constructed in accordance with the invention.

As shown in the drawing, a reconditioning system constructed in accordance with the present invention is embodied in a particle accelerator which comprises an evacuated envelope 10 composed of an electrical insulating material, such as out-gassed glass. Envelope 10 is evacuated, and as will be described hereinafter, is filled with ionizable gas, such as an isotope of hydrogen known as deuterium, at a selected pressure of 1 to 10 microns of mercury.

To derive ions of the gas within envelope 10, there is provided an ion source 11 including a tubular or cylindrical anode 12 and a pair of cathode plates 13 and 14 supported at opposite ends of cylinder 12. Connections from a medium-voltage power supply 15 to element 12–14 of ion source 11 are completed over leads which are suitably sealed in respective openings in envelope 10 in a known manner. A cylindrical magnet 16 receives envelope 10 and is essentially coextensive with anode cylinder 12. The ion source just described is disclosed in the copending application of John T. Dewan, filed April 9, 1952, bearing the Serial No. 281,378 and assigned to the same assignee as the present invention.

Some of the ions which are derived in source 11 may pass through an opening 17 in cathode plate 14 and are thereby introduced to an accelerating gap 18 via an opening 19 of a probe electrode 20 included in the accelerating gap. Also included in the accelerating gap 18 is a target assembly 21, and the accelerating gap is energized by a high voltage power supply 22. The spacing between the electrodes of accelerating gap 18 is selected in a known manner, in view of the voltage supplied by the source 22, so that no ionization occurs within the accelerating gap, while particles are accelerated to a velocity sufficient to react with a selected target substance, such as the isotope of hydrogen, tritium, to produce neutrons.

Target assembly 21 comprises a cylindrical member 23, constructed of a metal having a thermal coefficient of expansion similar to that of glass envelope 10, such as an alloy of nickel, cobalt, manganese and iron, commonly referred to as Kovar. Cylinder 23 is suitably

fused or sealed to the periphery of an opening 24 in the lower end of envelope 10 and its upper end is closed by a tungsten backing plate 25 suitably attached thereto, such as by silver soldering techniques.

Backing plate 25 may be of planar construction or may be of the alternate construction shown in the copending application of Clark Goodman, filed May 26, 1954, bearing the Serial No. 432,345 and assigned to the same assignee as the present invention. According to the alternate construction, backing plate 25 may be deformed so as to comprise a plurality of concentric corrugations.

The upper surface of backing plate 25 is covered in its entirety by a target element 26 which may be composed of a layer of a material absorbent to tritium, such as zirconium. Layer 26 is made thin in order to minimize the amount of tritium required but is sufficiently thick to permit accelerated particles to react completely with tritium gas which may be absorbed thereby during a process in accordance with the present invention, as will be more fully described hereinafter. Layer 26, for example, may be 1 to 10 microns in thickness and preferably should be adapted to form a stable hydride at a temperature occurring under normal operating conditions of the accelerator. Moreover, it should be fusable to the metal of backing plate 25 and should not flake off when hydrided with the selected isotope of hydrogen.

Element 26 is selectively absorbent to tritium at certain temperatures within a range from 400° to 600° C. This temperature may be obtained by means of a heater coil 27 located adjacent to, but electrically insulated from, the lower surface of backing plate 25. For example, coil 27 may be a flat spiral separated from plate 25 by a thin mica disc. One end of coil 27 is connected to the inner surface of cylinder 23 and its other end extends through an insulating sleeve 28 at the lower end of cylinder 23. Coil 27 may be energized by a battery 29 which may be selectively connected thereto via an operating switch 30.

In accordance with the present invention, there is provided a first gas-storing mechanism 31 having its lower end in communication with the upper end of envelope 10 via a thin tube 32. The upper end of the tube is flared outwardly to form a valve chamber 33 enclosing a valve element 34 having a uniformly ground conically shaped exterior adapted to cooperate with a ground glass seat 35 at the upper end of chamber 33. The valve element 34 is connected to a soft iron actuator or armature 36, preferably enclosed by a glass layer 37. A quartz compression spring 38 disposed between the lower end of actuator 36 and a shoulder 39 formed by the junction between tube 32 and valve chamber 33 normally forces the valve into its closed position.

To open the valve, there is provided a solenoid 40 which receives valve chamber 33. The solenoid is supported adjacent armature 36 and may be selectively energized by a battery 41 via an operating switch 42.

The upper end of valve chamber 33 is connected by an integral tube 43 to a heater chamber 44. The upper end of the heater chamber is closed by a seal 45 through which sealed leads pass so that connections may be introduced to a heater or filament 46. Filament 46 may be comprised of a thin zirconium wire spirally wound on a supporting wire of tungsten. Alternatively, a wire core constructed of molybdenum, stainless steel, or oxide coated steel may support a pair of wires wound in parallel, interspersed relation to one another. One of the latter wires may be composed of tungsten or molybdenum whereas the other wire may be composed of zirconium as disclosed in the copending application of Arthur H. Frentrop, filed March 8, 1954, bearing the Serial No. 414,839 and assigned to the same assignee as the present invention.

Heater 46 is hydrided with deuterium gas in a known manner and may be energized by a battery 47 via an operating switch 48. A variable resistor 49 is provided so that filament 46 may be raised selectively to its deuterium-absorbing temperature in a range from 300° to 600° C. or to its deuterium-emitting temperature in a range from 600° to 800° C. Of course, the emitting and absorbing temperatures are dependent on the gas pressure within the closed system including envelope 10 and gas-storing mechanism 31 and thus the required temperatures may be selected in a known manner.

The reconditioning system embodying the present invention further comprises a second gas-storing mechanism 50 which may be of a construction identical to mechanism 31. Mechanism 50 is in communication with envelope 10 via a tube 51 and is provided with a valve 52 normally biased against a seat 53 by a quartz spring 54. Its armature 55 is under the influence of a solenoid 56 which may be energized by battery 57 via an operating switch 58. As in mechanism 31, a zirconium filament 59 may be energized by a battery 60 via an operating switch 61 and a rheostat 62 is provided to control the operating temperature of filament 59. However, filament 59 is hydrided with tritium.

In constructing the accelerator shown in the drawing, target assembly 21 is sealed into glass envelope 10 before mechanisms 31 and 50 are attached and the assembly is thoroughly out-gassed in a known manner. Thereafter, tubes 32 and 51 are suitably fused to envelope 10 in an atmosphere of argon, the temperature of mechanisms 31 and 50 being maintained below approximately 300° C. during this procedure, and the envelope is evacuated and sealed.

To hydride target layer 26 with tritium, switch 58 is closed thereby energizing solenoid 56 and under the influence of the magnetic field of the solenoid, armature 55 moves downwardly thereby opening valve 52—53. During this operation, valve 34—35 is maintained closed by spring 38.

Switch 61 is then closed and rheostat 62 adjusted so that filament 59 is heated to a temperature in a range from 600° to 800° C. at which tritium gas is released. The gas flows through the open valve 52—53, through the convolutions of spring 54 and through tube 51 into envelope 10.

Switch 30 is then closed so that heater 27 may be energized by battery 29 and backing plate 25, together with layer 26, is raised to a temperature in a range from 400° to 600° C. at which layer 26 readily absorbs tritium. Accordingly, layer 26 is hydrided and switch 30 is then opened. To absorb excess tritium from envelope 10, rheostat 62 is adjusted so that filament 59 is reduced to a temperature in a range from 300° to 600° C. at which it absorbs tritium. After a suitable interval of time in which all the tritium is absorbed, except for that retained by target layer 26, switch 61 is opened. Finally, switch 58 is opened, thereby closing valve 52—53.

In order to introduce deuterium gas into envelope 10, switch 42 is closed and battery 41 energizes solenoid 40. Thus, armature 36 is drawn downward to open valve 34—35. Thereafter, switch 48 is closed and rheostat 49 adjusted to effect a temperature at filmant 46 in a range from 600° to 800° C. at which deuterium is emitted. By means of a suitable pressure-measuring device (not shown) which may be connected to envelope 10, this process is continued until a desired gas pressure in a range from 1 to 10 microns of mercury is obtained and thereafter, switches 48 and 42 are opened.

The accelerator thus is ready for operation and power supplies 15 and 22 may be energized. Ion source 11 operates in the manner described in the above-mentioned Dewan application and the deuterium gas within the ion source is ionized. Some of the derived positive ions drift toward cathode 14 and pass through opening 17. Since probe 20 is slightly negative relative to cathode 14, ions are attracted toward the probe. Some pass through opening 19 and are thus exposed to the high

accelerating potential applied between probe 20 and target layer 26 in which tritium is absorbed. Accordingly, highly accelerated deuterium ions react with tritium in target layer 26 to produce neutrons having an energy level in the neighborhood of 14 million electron volts.

As the particle accelerator continues to operate and deplete the tritium contained by layer 26, the neutron yield falls off. This may be indicated by a suitable detector responsive to the neutron output of the particle accelerator.

In order to replenish the target layer, power supplies 15 ad 22 are de-energized and switches 42 and 48 are closed. Rheostat 49 is adjusted so that filament 46 attains a deuterium-absorbing temperature and in this manner the pressure of deuterium within envelope 10 is reduced below the normal operating level. When the pressure has been sufficiently reduced, switches 42 and 48 are opened.

Tritium is then introduced to envelope 10 by closing switches 58 and 61 and layer 26 is heated to tritium-absorbing temperature by closing switch 30, in the manner described hereinbefore. After replenishment with tritium, switches 30, 58 and 61 are opened and switches 42 and 48 are closed. The latter switches permit the reintroduction of deuterium gas from filament 46 in the manner described hereinbefore.

In the final step of reconditioning, switches 42 and 48 are opened and the power supplies 15 and 22 may again be energized.

It is thus evident that the method and apparatus in accordance with the present invention permits the renewal or replenishment of the target element in a particle accelerator to be accomplished in situ and that the accelerator need not be disassembled for this purpose.

This desirable feature permits the accelerator tube to be sealed off and mounted within apparatus designed for operation remote from control equipment. For example, it is suited to the requirements of apparatus adapted to traverse a borehole, such as described in detail in the copending application of Clark Goodman, filed March 11, 1952, bearing the Serial No. 275,932 and assigned to the same assignee as the present invention. In such an environment, long continuous operation at constant neutron intensity is desirable and thus, after one or more logging runs, the method of target reconditioning embodying the present invention may be carried out at the surface of the earth. Thus, power for filaments 46 and 59, heater 27, and the various valve operators need not be supplied over the logging cable. The proper external connections may be made after the equipment has returned to the surface.

Although the present invention has been shown in association with a specific type of particle accelerator, it is evident that the method and apparatus may be employed in connection with reconditioning the target of any of a variety of accelerators. Accordingly, for any other application, tubes 32 and 51 of mechanisms 31 and 50 may be suitably connected to the envelope of the accelerator and the target layer is provided with a suitable backing member and a heater.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects, and therefore, the aim of the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In combination with an element of a particle accelerator having an envelope, a reconditioning system for said element comprising: a gas-storing mechanism in communication with said envelope having gas-emitting and gas-absorbing operating conditions; a control valve for interrupting gas communication between said mechanism and said envelope; means for selectively operating said control valve to establish gas communication between said mechanism and said envelope; means for conditioning said element to absorb gas; and means for selectively establishing said gas-emitting operating condition in said mechanism to introduce gas into said envelope for absorption in said element and for selectively establishing said gas-absorbing operating condition in said mechanism to absorb excess gas from said envelope.

2. In combination with an element of a particle accelerator having an envelope, a reconditioning system for said element comprising: a gas-storing mechanism having gas-emitting and gas-absorbing operating conditions; means for fluidly connecting said mechanism with said envelope including a tubular valve chamber; a control valve disposed within said chamber and including a valve seat and a member movable toward said valve seat for interrupting gas communication between said mechanism and said envelope, at least a portion of said member being constructed of a magnetic material; a solenoid enclosing a portion of said valve chamber; means for selectively energizing said solenoid to establish a magnetic field and displace said member thereby to operate said control valve; means for conditioning said element to absorb gas; means for selectively establishing said gas-emitting operating condition in said mechanism to introduce gas into said envelope for absorption in said element and for selectively establishing said gas-absorbing operating condition in said mechanism to absorb excess gas from said envelope.

3. In combination with an element of a particle accelerator having an envelope containing a first gas, a system for reconditioning said element with a second gas comprising: first and second gas-storing mechanisms in communication with said envelope having gas-emitting and gas-absorbing operating conditions and individually containing one of said first and second gases; means for selectively establishing said gas-absorbing operating condition in said first mechanism to absorb said first gas and for selectively establishing said gas-emitting operating condition to admit said first gas to said envelope; means for conditioning said element to absorb gas; and means for selectively establishing said gas-emitting operating condition in said second mechanism to introduce said second gas into said envelope for absorption in said element and for selectively establishing said gas-absorbing operating condition in said mechanism to absorb excess amounts of said second gas from said envelope.

4. A method of treating an element having a temperature-dependent absorbing characteristic for a selected gas in a particle accelerator having an envelope containing one gas at a given operating pressure which comprises the steps of: reducing the pressure of said one gas within said envelope below said given operating pressure; introducing said selected gas to said envelope of said particle accelerator; increasing the temperature of said element to a value at which said selected gas may be absorbed; reducing the temperature of said element below said value; reducing the pressure of said selected gas within said envelope; and introducing said one gas to said envelope to attain said given pressure.

5. In association with an element having a temperature-dependent absorbing characteristic for a selected gas in a particle accelerator having an envelope and provided with first and second temperature-controlled gas-emitting and absorbing devices containing one gas and said selected gas, respectively, and in communication with said envelope, and said envelope normally containing said one gas, a method of treating said element which comprises the steps of: heating said first device to a gas-absorbing temperature within an operating range of values to reduce the pressure of said one gas in said envelope; reducing the temperature of said first device below said operating range; heating said second device to a gas-emitting temperature within said operating range there-

by to introduce said selected gas to said envelope of said particle accelerator; increasing the temperature of said element to a value at which said selected gas may be absorbed; reducing the temperature of said element below said value; reducing the temperature of said second device to a gas-absorbing value within said operating range thereby to remove an excess of said selected gas from said envelope; heating said first device to a gas-emitting temperature within said operating range to introduce said one gas to said envelope; and reducing the temperature of said first device below said operating range.

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