NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

JUN 21 1974

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No.	: 3,816,785
Government or Corporate Employee	: Cal/Tech Pasadena, CA
Supplementary Corporate Source (if applicable)	: JPL
NASA Patent Case No.	: NPO-13,112-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES /X/ NO /_/

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

Bonnie L. Woerner

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Enclosure

(NASA-Case-NPO-13112-1) DISPENSING TARGETS FOR ION BEAM PARTICLE GENERATORS Patent (NASA) 6 p CSCL 14B

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Unclas 00/11 41108

United States Patent [19]
Miller

[11] **3,816,785**
[45] **June 11, 1974**

[54] **DISPENSING TARGETS FOR ION BEAM PARTICLE GENERATORS**

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[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, D.C.

[22] Filed: **June 29, 1972**

[21] Appl. No.: **267,572**

[52] **U.S. Cl.** .... **313/61 S, 250/499**
[51] **Int. Cl.** **G21g 3/04**
[58] **Field of Search** .... 250/499, 500; 313/61 S; 204/193

[56] **References Cited**

UNITED STATES PATENTS

3,646,348 2/1972 Detaint 250/499

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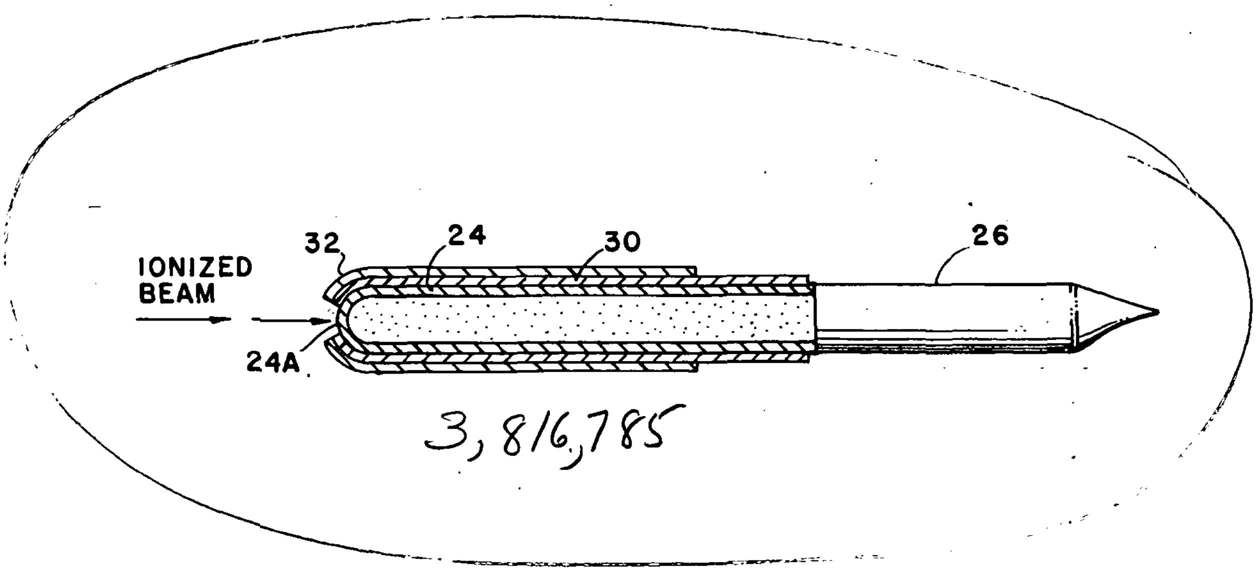
Attorney, Agent, or Firm—Monte F. Mott; John R. Manning; Paul McCaul

[57] **ABSTRACT**

A target for dispensing high energy protons or neutrons or ionized atoms or ionized molecules is provided which comprises a container for the target gas, which is at atmospheric or higher pressure. The container material can release the target gas in the spot where the container is heated above a predetermined temperature by the impact of an ion beam where protons or neutrons are desired, or by electrons where ionized atoms or molecules are desired. On the outside of the container, except for the region where the beam is to impact, there is deposited a layer of a metal which is imperious to gaseous diffusion. A further protective coating of a material is placed over the layer of metal, except at the region of the ion impact area in order to adsorb any unreacted gas in the vacuum in which the target is placed, to thereby prevent reduction of the high vacuum, as well as contamination of the interior of the vacuum chamber.

14 Claims, 4 Drawing Figures



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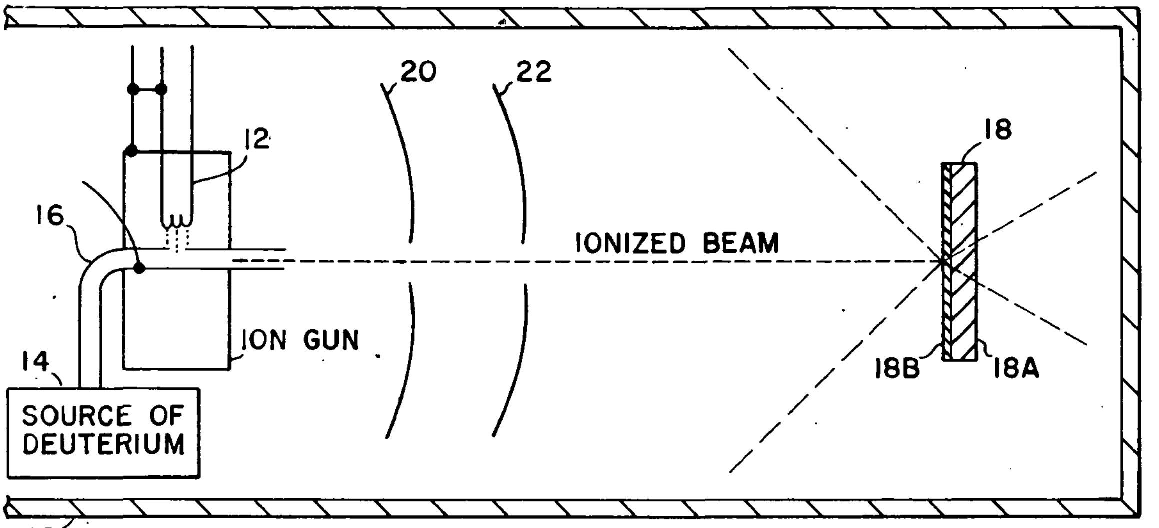

FIG. 1

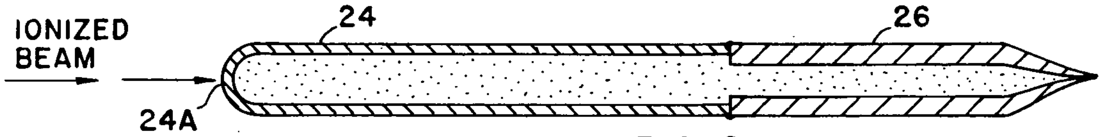

FIG. 2

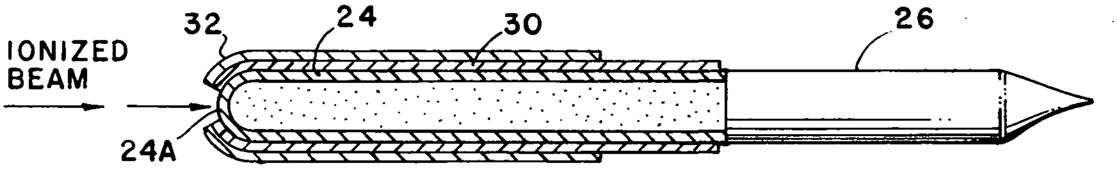

FIG. 3

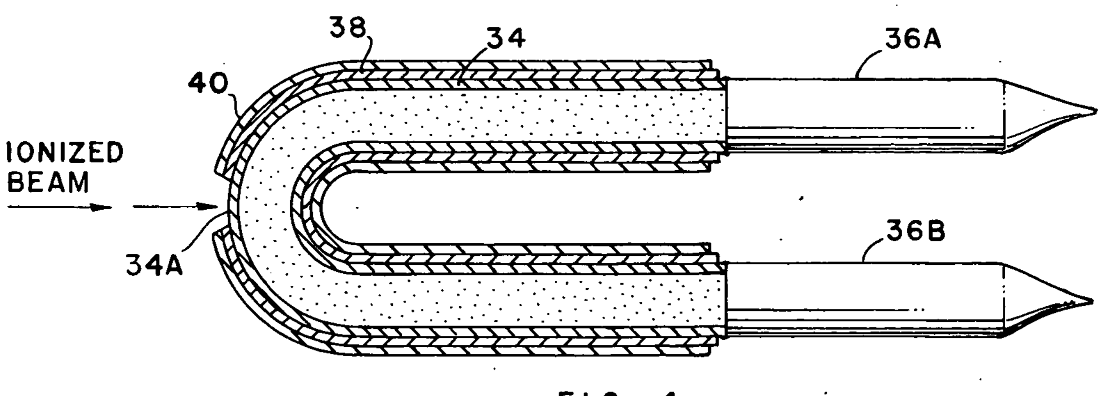

FIG. 4

DISPENSING TARGETS FOR ION BEAM PARTICLE GENERATORS

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

This invention relates to atomic particle generators and, more particularly, to targets for fast neutron or proton generators.

In a conventional proton or neutron generator an ion beam is generated in an ion gun by electron bombardment of deuterium gas or of helium-3, and the ions are drawn through an evacuated chamber by a potential difference of, on the order of 200 kV, to impinge on a target. In a typical neutron generator, the target is a metal disc or a substrate supporting a very thin layer (on the order of 0.001 mm thick) of titanium or zirconium. Atoms of tritium gas are bound to the thin titanium or zirconium layer by adsorption. When these tritium atoms are struck by the fast moving 200 kV deuterium ions from the ion gun, neutrons of 14 MeV energy are released.

The stability of the binding of the tritium in titanium or zirconium is low, and its stability decreases rapidly with increasing temperature. For this reason, manufacturers recommend that targets should be stored for short periods only. Since the adsorbed gas releases freely at temperatures of above about 100° C, the usefulness of such targets is limited to lower ambient temperatures, which requires forced cooling of the targets. More importantly, it requires the use of a defocussed beam in order to avoid overheating, so that a very small focal spot with its attendant high surface temperature is not useable. For many potential applications, such as neutron radiography or geological strata location, a small focal spot is essential. Furthermore, since in neutron generators, the target-bound gas is tritium, release not only reduces the desired high vacuum, but also produces radioactive contamination of the interior of the chamber. This type of target has a relatively short life, and radioactive decontamination is required each time the target is replaced.

OBJECTS AND SUMMARY OF THE INVENTION

An object of this invention is the provision of a dispensing target for deuterium or tritium which is more stable than dispensing targets which have been used heretofore.

Still another object of this invention is the provision of a dispensing target of the type described which is much more stable with increasing temperature than those which are used heretofore.

Yet another object of this invention is the provision of a dispensing target of the type described which acts to prevent loss of vacuum as well as contamination of the chamber in which the target is placed.

Still another object of the present invention is the provision of a novel and useful target for dispensing high energy neutrons or protons, or ionized atoms or molecules.

These and other objects of the invention may be achieved by providing a container for the gas, which may be deuterium or tritium, which container is a thin membrane made of a metal such as palladium, or palladium-silver alloy, or others to be described, which can permit diffusion therethrough of the gas when it is heated. The membrane is coated with a metal which is impervious to the diffusion of the contained gas, except at an exit point on the container. A further coating of a material such as titanium or zirconium is used to cover the exterior, except at the exit point, to provide adsorption of any unreacted deuterium or tritium which serves to both maintain the vacuum in which the target is placed, as well as to prevent contamination of the walls of the chamber.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing illustrating a conventional neutron generator.

FIG. 2 illustrates one embodiment in cross-section of a target for a generator, in accordance with this invention.

FIG. 3 is a cross-sectional drawing of another embodiment of this invention.

FIG. 4 is a cross-sectional drawing of a preferred embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a schematic drawing of a neutron generator, of the type known in the prior art, which is shown to provide an appreciation of this invention. The neutron generator comprises a container **10**, which contains the elements of the generator in a high vacuum. An ion beam is generated by heating a filament **12**, electrically, so that electrons which are emitted therefrom can bombard deuterium gas provided from a source of deuterium gas **14**, as it flows through a tube **16**. A suitable orifice is provided in the tube to admit the electrons, without losing the deuterium gas.

Ions, which are created as a result of such bombardment, are directed, by establishing a suitable potential difference, into the evacuated chamber to bombard a target **18**. Electrostatic lenses **20, 22** are used to converge or focus the diverging ionized deuterium beam.

The target comprises a substrate **18A**, on which there is deposited a very thin layer, **18B**, of a metal such as titanium or zirconium. Atoms of tritium gas are bound to the thin titanium or zirconium layer by adsorption. The ionized beam, which contains fast moving 200 kV deuterium ions, strike the surface of the target and release 14 MeV neutrons therefrom.

As indicated previously, since the adsorbed gas from the target releases freely at temperatures above about 100° C, the target must be used at ambient temperatures lower than 100° C. To avoid overheating by the impinging beam, a defocussed beam is used so that a very small focal spot with its attendant high surface temperature may be avoided. Since in the neutron generators, the gas which is released is tritium, not only does the released tritium reduce the desired high vacuum in the container surrounding the target, but also it produces radioactive contamination of the interior of the chamber, which requires decontamination before a target can be replaced.

FIG. 2 is a view in section of an improved target, in accordance with this invention. It comprises a thimble shaped container, **24** of a metal which may be either palladium, palladium-silver alloy, or nickel or tantalum, which is closed at one end and opened at the other end. The metal has the property that when its temperature is elevated above a predetermined value it permits the gas in the container to pass therethrough. The open end of the container is brazed or welded to a copper tubulation **26.** This permits a pinch-off to be readily effected after charging the container with the appropriate gas. The container may be on the order of 3 mm in diameter with a selected wall thickness typically about 0.1 mm. Its length can be up to 30 mm overall, including the copper tubulation. Such a container would hold about 2 ml (STP) of gas under 10 atmospheres pressure. This amount of the tritium gas contains 6 curies, which is equal to typical presently used titanium or zirconium targets.

When this target is in use, the ion beam impacts some minute area on the dome shaped end (**24A**) of the thimble to produce a local hot spot at a temperature of 200°–300° C, which is high enough to permit diffusion of the hydrogen isotope gas through the thin, palladium membrane into the much lower pressure vacuum chamber. As before, the ion beam collides with the diffusing gas atoms near the surface to liberate fast neutrons (or protons, depending upon the chosen reaction).

The structure described thus far, as well as those to be described subsequently, are also suitable for dispensing gas which when impacted by an electron beam will produce ionized molecules and/or ionized atoms. Bombardment of deuterium or tritium by electrons would produce ionized atoms or molecules of these materials. If the container is made of other materials such as silver, and is then filled with oxygen, an electron beam bombarding the dome of the thimble, can raise its temperature until the oxygen gas can escape to be bombarded by electrons. This can produce 0_2^- and 0^-. Other materials for the capsule and gases to be contained therein and to be dispensed in the manner described, will be obvious, from the foregoing, to those skilled in the art.

Although the beam contact area is very small, a temperature gradient extends from the point of impact to other portions of the dome end of the target. The temperature could be sufficiently high in adjacent areas, so that some of the gas could seep out beyond the reach of the ion beam. Such a diffused gas would reduce the chamber vacuum, and in the case of tritium target gas, would also contaminate the chamber interior with radioactivity. It is, therefore, desirable to reduce the possible effects of such unwanted diffusion.

FIG. 3 is a view in section of a preferred embodiment of this invention, which overcomes the effects of the unwanted diffusion. Parts of the structure which are similar to the structure in FIG. 2 have the same reference numeral applied thereto. The unwanted diffusion effects are minimized by coating the exterior of the palladium portion of the dispensing target with a metal **30,** which is impervious to the diffusion of contained gas when hot. The entire palladium region is coated with this metal, except for an exit point at the dome **24A,** which is bombarded by the beam. This can be achieved by masking this area during the deposition of the coating. Such coating can be a material such as copper, platinum, silver, or molybdenum.

A further coating **32,** of a target gas adsorbing material such as titanium or zirconium, or of a suitable rare earth metal such as erbium, on top of the protective coating **30** serves to adsorb unreacted deuterium or tritium and serves to maintain the vacuum in the chamber in which the target is placed, at the desired level of less than 10^{-4} torr during operation.

Since, in operation, a temperature gradient is established along the container, away from the hot spot at which the ionized beam strikes the palladium tube, toward the cooled pinch-off, at some distance along the coating, the temperature of the titanium reaches an optimum to adsorb and hold either deuterium or tritium. The optimum active area need only be 1 millimeter wide and 0.1 millimeter thick to scavenge all of the tritium in a 2 cc (STP) or 6 curie source if necessary. Such optimum temperature conditions are sure to be reached somewhere along the palladium sleeve during operation, and can maintain high vacuum in an operating device.

FIG. 4 shows a more readily fabricated version of the embodiment of the invention. The target here comprises a tube **34,** of palladium-silver alloy bent into the shape of a hairpin, with copper tubulations, **36A, 36B,** welded or brazed to the open ends of the tubing. The palladium-silver alloy has a coating **38** of a metal impervious to diffusion by the contained gas, which is applied to all of its surface except for the region of the dome end which is bombarded by the ionized beam. On the coating **38,** there is applied another coating **40** of a material which serves to adsorb the unreacted gas which is released from the container under the action of the ionized beam. The use of two copper terminations makes charging of gas easier, since one of these terminations can be used to pull a vacuum in the tube before filling through the other, followed by a subsequent pinch-off of both.

Some possible uses for the dispensing target are in neutron-radiography investigations, nuclear safeguard studies, and logging of exploratory oil well bores in search for new sources of oil. Neutron generators have been used for this purpose for many years but the available instruments have serious limitations.

Isotope type neutron generators find use in oil well exploration. In one arrangement currently being used an isotope, such as Po–210 or Ra–226 is contained with beryllium in a capsule. The interaction produces neutrons, but the long life Ra–226–Be produces much gamma radiation which is not useful. In order to interpret the readings obtained by well bore exploration, a gamma ray detector must also be used in addition to a neutron detector, so that the unwanted effect of the gamma radiation can be subtracted from the readings. The Po–210-Be source, which lacks the interfering gamma rays, has, however, a limited half life of about 138 days, and the rate of neutron production is constantly decreasing day by day. In practice, this means that the rate of scanning (the movement upward or downward in the well bore) must be adjusted constantly with increasing time necessary as the decay proceeds.

A so called "machine" source of neutron generation is capable of more constant rates of neutron generation, and in addition produces mainly fast neutrons which are more useful in generating the desired information. However, the presently available targets are merely variations of the one shown in FIG. 1, and thus have the same limitations of a relatively short life and the possibility of radioactive contamination. A more fundamental limitation on the use of such machines is that they cannot be operated in ambient temperatures approaching the release point of the adsorbed gas from the titanium or zirconium film. Present generators therefore cannot be used in deep well bores subject to increasing temperature in proportion to depth. The present invention overcomes this limitation and permits its use at much lower depths than well bores than is at present possible.

There has accordingly been shown and described herein a novel, useful target for fast neutron generators.

What is claimed is:

1. A gas dispensing target for use in a particle generator of the type wherein a region of said target is heated by the bombardment of ions or electrons to release gas which is within said container at the precise spot at which it is bombarded and thus most efficiently acted upon by the bombarding ions or electrons, said target comprising

a container made of a metal,

a gas within said container made of a metal,

the metal of said container having the property that it will only permit gas to escape from the region of said container whose temperature is elevated above a predetermined threshold.

2. A target as recited in claim **1** for use in a fast neutron or proton generator wherein the gas in said container is a hydrogen isotope, and wherein

said target is made of one of the metals in a group consisting of palladium, palladium-silver alloy, nickel and tantalum.

3. A target as recited in claim **1** for use in an ionized atom or ionized molecule generator wherein

the gas in said container is one of the gases selected from a group consisting of a hydrogen isotope and oxygen, and

said container is made of one of the metals in a group consisting of palladium, palladium-silver alloy, nickel, tantalum, and silver.

4. A target as recited in claim **1** wherein:

said container is coated over its entire surface, except in a region to be heated to permit gas escape therethrough, with a metal having the property that it is impervious to the gas with which the container is filled at the temperature at which said container permits gas to escape therethrough, and

a coating over the metal coating of a material which has the property that it can adsorb the gas with which the container is filled when its temperature reaches a predetermined threshold.

5. A target as recited in claim **1** wherein the container is thimble shaped.

6. A target as recited in claim **1** wherein the container is U-shaped.

7. A target as recited in claim **4** wherein the metal coated over the surface of said container is one selected from a group consisting of copper, platinum, silver, and molybdenum.

8. A target as recited in claim **4** wherein the coating over the metal coating is one selected from a group consisting of titanium, zirconium, and erbium.

9. A target for dispensing gas in response to ion or electron beam bombardment comprising:

a thimble shaped container having walls which are pervious to a gas contained therein when the temperature of said walls exceed a predetermined threshold,

a copper closure brazed to the open end of said thimble for affording closure of said container,

a metal coating over all of said container except the copper closure, and the region bombarded by said ion or electron beam, said metal coating being imperious to said gas at the temperature at which said container is pervious to said gas,

a coating over said metal coating of a material which can adsorb the gas within said container when its temperature reaches a predetermined threshold, and

a gas within said container.

10. A target for dispensing gas in response to ion or electron beam bombardment comprising:

a U-shaped container having walls which are pervious to a gas contained therein when the temperature of said walls exceed a predetermined threshold,

copper closures brazed to the open ends of said U-shaped container for affording closure of said container,

a metal coating over all of said container except the copper closures, and the region bombarded by said ion or electron beam, said metal coating being impervious to said gas at the temperature at which said container is pervious to said gas,

a coating over said metal coating of a material which can adsorb the gas within said container when its temperature reaches a predetermined threshold, and

a gas within said container.

11. A target as recited in claim **9** wherein the container is made of one of the metals selected from a group consisting of palladium, a palladium-silver alloy, nickel, and tantalum,

said metal coating is one of the metals selected from a group consisting of copper, platinum, silver, and molybdenum,

said coating over said metal coating is one of the materials selected from a group consisting of titanium, zirconium, and erbium.

12. A target as recited in claim **10** wherein the container is made of one of the metals selected from a group consisting of palladium, a palladium-silver alloy, nickel, and tantalum,

said metal coating is one of the metals selected from a group consisting of copper, platinum, silver, and molybdenum,

said coating over said metal coating is one of the materials selected from a group consisting of titanium, zirconium, and erbium.

13. A gas dispensing target for use in a particle generator wherein a region of said target is heated by bombarding it with ions or electrons to release gas which is within said container at the precise spot at which it is bombarded to thereby be most efficiently acted upon by bombarding ions or electrons, said target comprising a container for said gas, the wall of all of said container except for said region which is bombarded comprising a metal which is impervious to said gas at the temperature to which said target is heated to permit the escape of gas,

the walls of said container at said region which is bombarded comprising a metal which is pervious to said gas when its temperature exceeds a predetermined value.

14. A gas dispensing target as recited in claim 13 wherein the wall of all of said container except for said region which is bombarded is further covered with a layer of material which will adsorb any gas released from said container which is not acted upon by said bombarding ions when the temperature of said material reaches a predetermined value.

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