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METHOD AND APPARATUS FOR PRODUCING NEUTRONS

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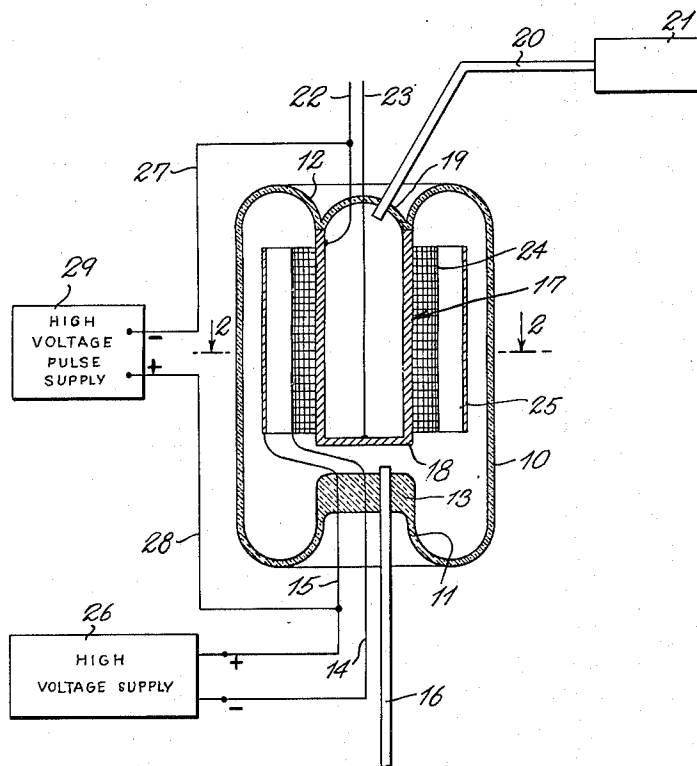


Fig. 1.

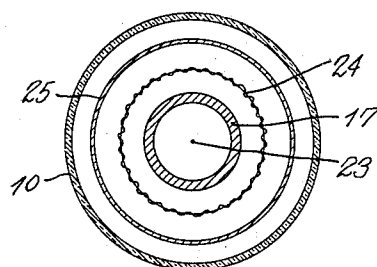


Fig. 2.

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METHOD AND APPARATUS FOR PRODUCING NEUTRONS

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This invention relates to neutron sources and more particularly to methods and means for producing electrically neutral particles having a mass of approximately protonic magnitude, and of which neutrons are typical.

A principal object of the invention is to provide a more efficient and readily controllable means for producing neutrons.

Another object is to provide a compact and relatively inexpensive apparatus for deriving neutrons from heavy hydrogen or deuterium.

A feature of the invention relates to a system for producing a copious supply of neutrons or the like by interaction between deuterium and deuterium ions.

Another feature relates to a device for producing neutrons employing an evacuated chamber containing therein a receptacle which can be replenished with heavy hydrogen or deuterium, the wall of said receptacle forming a closure for said evacuated chamber and arranged to be heated to provide a continuous supply of heavy hydrogen or deuterium within said evacuated chamber; means being provided to produce energy interaction between positive deuterium ions within said chamber and with the said deuterium therein to generate a copious supply of neutrons.

Another feature relates to a device for producing neutrons, which comprises two chambers having a common dividing wall of a material of high electrical conductivity which, when heated, is pervious to heavy hydrogen or deuterium, one of the chambers being evacuated and enclosing at least one ion-producing and ion-accelerating electrode, the other chamber being connected to a supply of heavy hydrogen or deuterium.

Another feature relates to a device for producing neutrons, comprising an enclosing evacuated chamber with a reentrant wall portion of palladium which is arranged to be connected to a source of heavy hydrogen or deuterium, and also arranged to be heated. Located within the device are two or more ion-producing and ion-accelerating electrodes which are arranged to be energized with high voltage pulses to cause positive deuterium ions to bombard the hydrogen or deuterium as it emerges at the surface of said palladium portion.

A further feature relates to an arrangement for generating neutrons by energy interaction between positive deuterium ions and a layer of deuterium, by utilizing high voltage electrical pulses to control the rate of energy exchange and bombardment of the deuterium by the positive deuterium ions.

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A further feature relates to an ion discharge device employing a central cathode in the form of a hollow palladium member one face of which is supplied with a quantity of heavy hydrogen or deuterium, the other face being located within an evacuated chamber or enclosing envelope; a foraminous electrode or grid and an anode are located in spaced relation to the cathode and are relatively biased to produce therebetween a supply of positive deuterium ions. A source of high voltage pulses is connected across the cathode and anode to cause the said ions to move backwardly through the said grid to bombard the cathode and thereby to produce a continuous supply of neutrons.

A still further feature relates to the novel organization, arrangement and relative location and interconnection of parts which cooperate to provide an improved neutron generator.

Other features and advantages not particularly enumerated, will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing,

Fig. 1 is a composite structure and schematic wiring diagram of a system of apparatus embodying the invention.

Fig. 2 is a cross-sectional view of the generator tube of Fig. 1 taken along the line 2—2 thereof.

Referring to the drawing which shows, in diagrammatic form, one preferred manner of practicing the concept of this invention, the numeral 10 represents any suitable enclosing chamber or envelope of glass or other similar suitable material which is substantially pervious to neutrons. While the envelope 10 is shown in the form of a cylindrical tube having reentrant ends or lips 11, 12, it will be understood that any other suitably-shaped envelope can be used. The reentrant portion 11 is closed-off by a press or seal 13 of glass and through which the lead-in wires 14, 15, are sealed in a vacuum-tight manner. The exhaust tubulation 16 also communicates with the interior of envelope 10 and is arranged to be connected to a suitable vacuum pump to maintain a predetermined evacuated condition within the envelope.

Sealed in a vacuum-tight manner to the other re-entrant portion 12 is a tubular or cylindrical member 17 the lower end of which is closed by the metal cap 18, and the upper end of which is hermetically sealed to a glass cap 19. The member 17 with its cap 18 are preferably formed as a unitary construction from the same metal. A supply tube 20 passes through cap 19 to com-

municate with the interior of member 17, and tube 20 is arranged to be connected to a source 21 of heavy hydrogen or deuterium. In accordance with one phase of the invention, the member 17 with its cap 18 is made of palladium. One advantage of using palladium is that it can have an extremely high density of heavy hydrogen within and on its surface. Member 17 and its cap 18 are arranged to be heated in any suitable manner, preferably electrically. For this purpose, a pair of lead-in wires 22, 23 are hermetically sealed through the cap 18 and are respectively connected to the upper end of member 17 and to the center of cap 18, so that by applying a suitable voltage to the wires 22, 23, the receptacle 17 can be raised to any desired temperature. Surrounding the cathode 17, and in spaced relation thereto, is a foraminous electrode or grid 24. Likewise surrounding the electrode 24 is a plate or anode 25, both the electrodes 24 and 25 being suitably supported in any well-known manner in their proper spaced relations and being connected respectively to the lead-in wires 14 and 15. Connected to the wires 14 and 15 is a source of high voltage D. C. supply 26 having its positive terminal connected by way of wire 15 to the anode 25, and its negative terminal connected by way of wire 14 to grid 24. Connected across the cathode 17 and anode 25 by means of conductors 27, 28, is a source 29 of high voltage D. C. pulses, the positive terminal of this source being connected by conductor 28 to the anode 25, and the negative terminal being connected by conductor 27 to the cathode 17.

The operation of the above described device for producing neutrons is substantially along the following lines. With the receptacle 17 supplied interiorly with a sufficient quantity of deuterium or heavy hydrogen, the member 17 is heated by electric current to a fairly low temperature within a typical operating range of 200° C. - 300° C., and preferably not over 800° C., in which condition the hydrogen or deuterium passes freely through the wall of member 17 and forms a layer or sheath on the inner surface of member 17 which is located within the evacuated space of envelope 10, and diffuses into the evacuated chamber. By reason of the high D. C. voltage applied between electrodes 24 and 25, a glow discharge is produced between these two electrodes giving rise to a large quantity of positively-charged ions of deuterium. By reason of the high voltage positive D. C. pulses which are applied to the anode 25, these positive deuterium ions are driven back through the grid 24 at relatively high velocity and collide with the deuterium which has seeped through the wall of member 17, the velocity being such as to give rise to a continuous supply of high velocity neutrons which can pass through the envelope 10 and can be collected by any suitable means.

While one particular embodiment has been described, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for generating neutrons comprising, an evacuated receptacle having a wall portion thereof formed of a metal which when heated is pervious to deuterium, means to apply deuterium to the surface of said wall portion which is external to said receptacle, means to heat said wall portion to render it pervious and to cause said deuterium to appear at the surface of said

wall portion which is interior of said receptacle, and an electrode system within said receptacle for ionizing deuterium which seeps through said wall portion and for accelerating the deuterium ions into high velocity collision with said deuterium and thereby to produce neutrons.

2. Apparatus for producing neutrons comprising, an evacuated envelope having a wall portion of palladium, means to apply deuterium to the surface of said wall portion external to said envelope, means to heat said wall portion to render it pervious to deuterium and to cause said deuterium to appear at the surface of said wall portion which is interior of said envelope, and an electrode system within said receptacle for ionizing said deuterium, and means to energize at least one electrode of said system by high voltage pulses to produce high velocity collisions between said ions and said deuterium to produce neutrons.

3. Apparatus for producing neutrons comprising, an enclosing evacuated envelope having a reentrant portion which when heated is pervious to deuterium, means to apply deuterium to the surface of said reentrant portion external of the envelope to cause the deuterium to appear at the surface of said reentrant portion which is interior of the envelope at least one deuterium ionizing electrode within said envelope, and means to bias said electrode positively with respect to said wall portion to drive the said ions into high velocity collision with said deuterium to produce neutrons.

4. Apparatus for producing neutrons comprising, an evacuated envelope, a cathode in the form of a metal receptacle connected to a supply of deuterium said receptacle being of a metal which when heated is pervious to said deuterium, an anode within said envelope supported in spaced relation with respect to the cathode, a foraminous electrode between said anode and cathode, means to heat said cathode to render it pervious to said deuterium, means to bias said anode and foraminous electrode with respect to each other to ionize said deuterium, and means to apply high voltage energy to said anode to drive the positive deuterium ions into high velocity collisions with said deuterium and thereby to generate neutrons.

5. Apparatus for producing neutrons comprising, an evacuated glass envelope having a hollow metal receptacle sealed in a vacuum-tight manner through its wall, said receptacle being supplied with a quantity of deuterium, means to heat said receptacle to render it pervious to said deuterium, an anode within said envelope surrounding said receptacle, a grid electrode located between said anode and said receptacle, means to apply high D. C. voltage between said anode and grid to ionize the deuterium, and means to apply high voltage D. C. pulses to said anode to accelerate the positive deuterium ions into high velocity collisions with the deuterium at the surface of said receptacle.

6. Apparatus for producing neutrons comprising an evacuated glass envelope having a reentrant portion of palladium, means to supply said reentrant portion externally with deuterium, means to heat said reentrant portion to render it pervious to said deuterium, a grid electrode surrounding said reentrant portion in spaced relation thereto, an anode surrounding said grid in spaced relation thereto, and means to bias said grid and anode with respect to each other and with respect to said reentrant portion to produce positive deuterium ions and to accelerate them into high velocity collisions with the

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deuterium which has seeped through the wall of said reentrant portion into said evacuated envelope.

7. The method of producing neutrons within an evacuated envelope which comprises, heating a portion of the wall of said envelope to render it pervious to a supply of deuterium, to produce on the inner surface of said wall portion a sheath of deuterium, producing within said evacuated envelope a supply of positive deuterium ions, and accelerating said ions into high velocity collisions with said sheath of deuterium.

8. The method according to claim 7 in which said acceleration is effected by high voltage electrical pulses

9. A device of the character described, comprising two closed receptacles having a common dividing wall of a metal which when heated is pervious to deuterium, one of said receptacles being evacuated and the other receptacle being connected to a supply of deuterium, means to heat said common wall to render it pervious to said deuterium, and a pair of deuterium ionizing and accelerating electrodes within said evacuated receptacle for producing high velocity collisions between deuterium ions and deuterium within said evacuated receptacle which has seeped through said common wall.

10. A device according to claim 9 in which said common wall is of palladium.

11. A device according to claim 9 in which said common wall is of palladium and means are provided for heating said common wall to render it pervious to deuterium.

12. A device comprising a source of deuterium ions, a target for said ions, said target being rich in deuterium and of high electrical conductivity and having one surface located within an evacuated vessel and the opposite surface external to

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said vessel, said source of deuterium being in contact with said external surface, and means to accelerate said ions to cause them to strike said target with a predetermined velocity.

13. A device according to claim 12 in which the means to accelerate said ions comprises a source of pulsed direct current potential.

14. Apparatus of the character described, comprising an evacuated receptacle having a portion of high electric conductivity and with one surface exposed to the vacuum within the receptacle, and the opposite surface exposed outside the receptacle, means to contact the external surface of said portion with a quantity of deuterium to produce deuterium at the opposite surface of said portion within said receptacle, and electrode means within said receptacle for producing deuterium ions and for bombarding said opposite surface with said ions.

15. Apparatus for generating neutrons, comprising an evacuated receptacle having a target electrode, a source of deuterium for supplying the surface of said electrode interiorly of said receptacle with a quantity of deuterium, a pair of electrodes cooperating with said target to bombard said target with deuterium ions, means to apply a steady ionizing potential across said electrodes, and means to apply a high voltage pulse potential across one of said electrodes and said target.

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REFERENCES CITED

The following references are of record in the file of this patent:

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