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ION SOURCE HAVING ELECTRODES OF CATALYTIC MATERIAL

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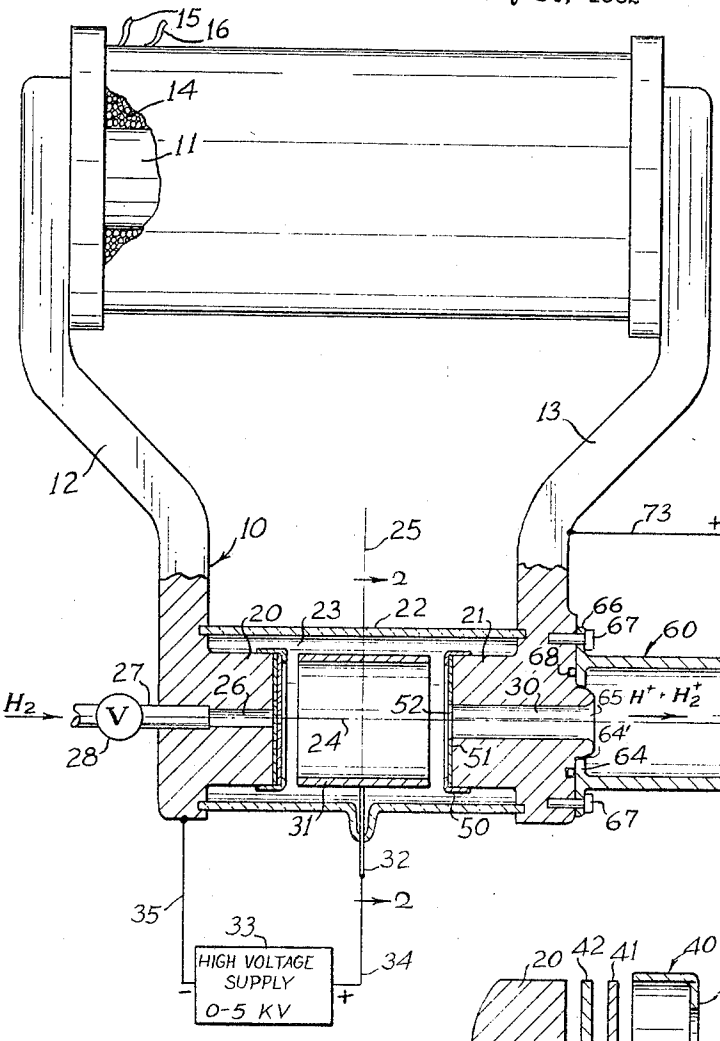


Fig. 1

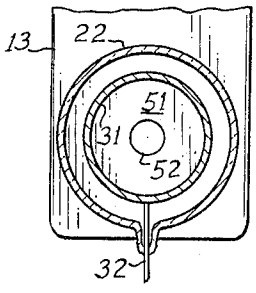


Fig. 2

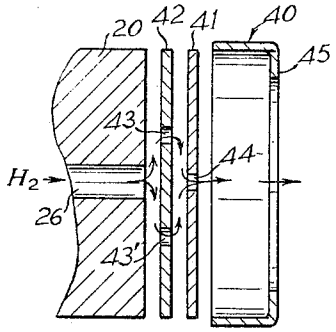


Fig. 3

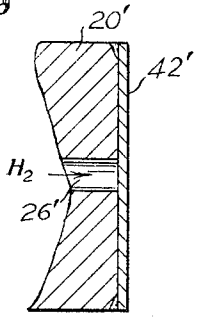


Fig. 4

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ION SOURCE HAVING ELECTRODES OF CATALYTIC MATERIAL

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This invention relates to an ion source and is more particularly concerned with an apparatus and process for ionizing molecular gases and accelerating the ions thereby produced. The present invention is particularly suited for producing atomic ions from the various isotopes of hydrogen such as protons, deuterons and tritons.

Ion sources are used for producing beams of positive ions which are accelerated by high voltages until the ions acquire large energies and are then directed against a target to produce a nuclear reaction. For this pupose, atomic ions are much more effective than molecular ions.

In the past, a variety of ion sources has been devised. Usually such prior art ion sources have either been bulky and expensive or have had a very low yield, i.e. ratio of atomic hydrogen to molecular hydrogen. A Penning ion source is an example of the latter type of ion source and is severely limited in its application because the extremly low ratio of atomic hydrogen to molecular hydrogen in the beam which it produces. Thus, if the ratio of atomic hydrogen to molecular hydrogen in the beam could be increased, the Penning ion source would be a much more useful device.

Briefly, I have devised a simple yet effective system by which the efficiency of an ion source and particularly a Penning ion source may be increased without materially increasing its weight, size or complexity. In general terms, the apparatus of the present invention includes the usual ion source such as a Penning ion source which I have modified by incorporating within the ionizing zone a metal catalyst so arranged that the gas to be ionized intimately contacts the catalyst immediately prior to or during a period in which the gas is being ionized, the heat incidentally created by the arc of the ion source being utilized for increasing the activity of the catalyst. The catalyst which I employ is a noble metal such as platinum, palladium, an alloy containing ether platinum or palladium or a substance having a high affinity for and which will render nascent, the particular gas to be ionized.

Accordingly, it is an object of the present invention to provide an apparatus and process for ionizing molecular gases and accelerating the ions thereby produced wherein the ratio of atomic ions to molecular ions in a beam is increased.

Another object of the present invention is to increase the efficiency of a Penning ion source.

Another object of the present invention is to provide an ion source which will create a beam which is high in atomic ions.

Another object of the present invention is to provide an ion source which is inexpensive to manufacture, durable in structure and efficient in operation, the ion source being well suited to the demands of mass production.

Another object of the present invention is to provide a process which is applicable to substantially any ion source for increasing the ratio of atomic gas to molecular gas in the beam, without materially increasing the complexity of the apparatus employed and without decreasing its overall efficiency.

Other objects, features and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings wherein like characters of reference designate corresponding parts throughout the several views and wherein:

FIG. 1 is a partially broken away, side elevational view of an ion source constructed in accordance with the present invention.

FIG. 2 is a cross sectional view taken along line 2—2 in FIG. 1.

FIG. 3 is an enlarged exploded vertical sectional view of a detail of the device shown in FIG. 1.

FIG. 4 is a vertical sectional view showing a detail relating to a modified form of the present invention.

Referring now in detail to the embodiment chosen for the purpose of illustrating the present invention, it being understood that in its broader aspects the present invention is not limited to the exact details herein depicted, numeral 10 denotes generally a U-shaped magnet of a conventional Penning ion source, the circular core 11 of which is disposed between the upper ends of a pair of opposed complementary legs 12 and 13. Surrounding the core 11 is a coil of wire 14, the ends 15 and 16 of which are connected to a source of D.C. current. The magnet 10, of course, is formed of a ferromagnetic material, such as iron or alnico or the like. The magnet 10 may either be a permanent magnet or an electromagnet since its function is to provide a constant field between the opposed lower ends of legs 12 and 13 and thereby impart curvilinear movement to the electrons, rather than continue in their rectilinear movement. Integrally formed respectively along the inner surfaces of legs 12 and 13 are a pair of opposed cylindrically shaped, ferromagnet cathode poles 20 and 21, the flat inner surfaces or faces of which are in spaced, essentially parallel relationship to each other, to define therebetween an ionizing zone.

Surrounding the ionizing zone and the cathode poles 20 and 21 is an insulating tubular housing 22, the opposite ends of which are recessed in the inner walls of the arms 12 and 13 to thereby provide a closed cylindrical chamber 23 which may be evacuated, the housing 22 being concentric with and of a larger diameter than the cathode poles 20 and 21. Thus, the housing 22 and the cathode poles 20 and 21 have a common main or longitudinal axis 24 while the housing 22 has a vertical center line or transverse medial axis 25 which is midway between the inner surfaces or faces of the cathode poles 20 and 21. Preferably, the housing 22 is formed of heat resistant glass, such as Pyrex, even though other insulation materials may be used.

Along the axis 24, the leg 12 and cathode pole 20 are provided with a bore which forms an inlet passageway 26 through which hydrogen gas (H_2), i.e. the deuterium, is introduced to chamber 23. It will be understood, of course, that other gases to be ionized may be introduced into the chamber 23 through passageway 26, if desired. For this purpose, the outer end of passageway 26 receives an inlet conduit 27 having an inlet valve 28, the conduit 27 communicating with a source of gas, such as hydrogen as indicated in FIG. 1 by the symbol H_2 and its accompanying arrow. In like manner, the leg 13 and the cathode pole 21 are provided with a bore along the axis 24 to form an outlet passageway 30 therethrough.

The passageways 26 and 30 are, therefore, in coaxial alignment, the inner ends or mouths of the passageways 26 and 30 communicating with the chamber 23 and being in spaced relationship to each other. The passageway 30 forms a channel through which a beam composed of atomic and molecular ions, as indicated by the symbols H^+ and H_2^+ is discharged.

For the purpose of creating the ions, there is positioned centrally within chamber 23 a hollow cylindrical

or tubular anode catalyst member 31 which is open at both sides. The anode member 31 is preferably of about the same diameter as the diameter of the cathode poles 20 and 21, being positioned coaxially, midway therebetween, the ends of the anode member being in spaced relationship to the faces of the cathode poles 20 and 21.

For supporting the anode catalyst member 31 and for supplying an electrical potential thereto, a metal rod 32 is connected by one end to the bottom central portion of the anode member 31 and protrudes therefrom, through the glass housing 22. The outer end of rod 32 is connected to the positive side of a high voltage supply 33, via wire 34. The other side of the high voltage supply 33 is connected via wire 35 to the magnet, namely to leg 12. The high voltage supply 33 provides a D.C. voltage from 0 to 5,000 volts, as will be understood by those skilled in the art. Hence, a potential may be set up between the cathode poles 20 and 21 and the anode member 31.

According to the present invention, the noble metal catalyst is disposed within the chamber 23. In the present embodiment the catalyst is in the form of palladium or platinum or an alloy containing palladium or platinum, such as silver-palladium disposed within the path of the incoming and outgoing gas and preferably deflecting the incoming gas temporarily from its normal path. In the forms of the present invention here illustrated, overlapping sheets of noble metal essentially close the mouth of the inlet passageway 26 to provide irregular paths of travel for the gas into the chamber 23 and similar sheets, having aligned opening, surround the mouth of passageway 30, the sheets covering the faces of the cathode poles 20 and 21. Also, the anode member 31 is formed from the catalyst metal or is plated with the catalyst metal.

As seen in FIGS. 1 and 3, the structure of the cathode catalyst includes a cap 40 which supports a plurality of flat baffle plates, such as plates 41 and 42. The cap 40 and plates 41, 42 are formed of the catalyst metal, the plates 41, 42 being disk shaped members corresponding to the diameter of the cathode pole 20.

The baffle plate 42 is provided with a plurality, i.e. a pair, of holes 43, 43', seen best in FIG. 3, the holes 43, 43' being offset from the center of the plate sufficiently to be in misalignment with passageway 26. Baffle plate 42 fits flat against the face of cathode pole 20 to effectively close the passageway 26, except that light gas therefore may leak from the mouth of the passageway 26 and pass outwardly along the inner urface of baffle plate 42 and eventually leak through holes 43, 43'.

The baffle plate 41 is placed on the outer surface of the plate 42 and is provided with a central hole 44 through which the gas passes, after passing through holes 43, 43', the gas moving inwardly between the outer surface of plate 42 and the inner surface of plate 41 in traversing the distance between holes 43, 43' and hole 44.

To retain the plates 41, 42 in place and to prevent any appreciable leakage of the gas from the periphery of plates 41, 42, the cap 40 has an annular face 45, the central opening of which is only slightly smaller than the diameter of the baffle plates 41, 42, and an annular flange extending from the outer periphery of annular face, sufficient to engage frictionally the periphery of the cathode pole 20 and thereby hold plates 41, 42 in place over the face of cathode pole 20.

A similar cap 50 is provided for the cathode pole 21 so as to hold a catalyst plate 51 over the surface of the cathode pole 21, the catalyst plate 51 having a central opening 52 of substantially the same diameter as the diameter of passageway 30.

It is now seen that the effective surfaces of both the cathode poles 20, 21 and the anode member 31 are covered with or formed of noble metal, such as platinum, palladium or an alloy containing platinum or palladium, inter alia palladium-silver alloy. It will be understood

also that, while I have disclosed a system in which both cathode poles 20 and 21 are covered by noble metal, the present device is useful even if only one of the pole surfaces is covered, preferably the surface of the cathode pole 20.

Bolted to the outer surface of the leg 13 is an accelerator tube denoted generally by numeral 60 which may include additional electrostatic mechanisms (not shown) for controlling and focusing the beam emitted from passageway 30 and for directing the beam against a target 61. The accelerator tube 60, by way of illustration, is a hollow cylindrical insulating casing 62 having an insulating disk 63 closing its outer end and an inner end 64 with a central aperture 64' surrounding the passageway 30. The inner end 64 is provided with a peripheral flange 66 through which bolts 67 pass into the leg 13.

When mounted by bolts 67, the inner end 64 is positioned flat against the outer surface of leg 13 whereby the central aperture of inner end 64 receives the annular lip 65 surrounding the end of passageway 30. Thus, tube 60 is aligned with the passageway 30 and the casing 62 is coaxially disposed with respect to passageway 30. An O ring 68 is in an annular groove in leg 13 around the exit end of passageway 30 and provides a seal between the tube 60 and the chamber 23.

Target 61 is supported by and electrically connected to shaft 69 which extends through disk 63. The shaft 69, in turn, is connected to ground and via wire 71 to the negative side of a high voltage supply 72, the positive side of voltage supply 72 being connected, via wire 73 to the leg 13. The voltage supply 72 imparts an electrostatic potential of approximately 100,000 volts between the lip 65 and target 61.

When neutrons are to be created from deuterons, the target 61, as is well known, is made of titanium, zirconium or some other metal in which is absorbed tritium.

Communicating with the interior of casing 62 is an evacuation system including an evacuation pipe 75 connected between a vacuum pump 76 and casing 62. When the pump 76 is operated, the pressure within the chambers 23, 60 is reduced.

Referring to the modified form of the present invention, as illustrated in FIG. 4, which may be substituted for the structure shown in FIG. 3, it will be seen that in place of cap 40 and plates 41, 42, a single thin sheet or plate 42' is fixed, as by welding, over the inlet of a passageway 26' and over the face of cathode pole 20'. Plate 42' is formed of platinum, palladium or an alloy containing one of those two metals, the plate 42' being sufficiently thin that the pressure differential between the chamber on the one side of plate 42' and the passageway 26' on the other side of the plate 42' will urge the incoming gas molecules through the plate 42', whereby the molecules are caused to move along circuitous paths therethrough so as to intimately contact the metal of plate 42'. The flow of the gas through the plate 42' is increased as plate 42' becomes heated, as a result of the electrical discharge.

In operation, a high vacuum is induced in the chamber 23 and accelerator tube 60 by actuation of the vacuum pump 76. At about the same time, the valve 28 is opened to admit the hydrogen (deuterium) via passageway 26 and the catalyst baffle plates 42 and 41 into the chamber 23. The valve 28 and pump 76 are operated such that an absolute vacuum of from .1 micron to 10 microns of mercury, preferably in the order of 1 micron of mercury (10^{-3} mm.), is created in chamber 23 and a higher vacuum of about 10^{-5} mm. of mercury is created in the accelerator tube 60.

Next, the coil of wire 14 is energized to create a static magnetic field of about 600 gauss between the cathode poles 20 and 21. Then the high voltage supply 72 is energized to create a potential between the Penning ion source and the target 61 of about 100,000 volts.

Finally, the high voltage supply 33 is energized to strike an arc between the anode member 31 and the cathode

poles 20 and 21. The electrical discharge thus creates a flow of electrons which cascade through chamber 23, creating an ionizing zone between the faces of the cathode poles 20 and 21. Because of the intense magnetic field, the electrons tend to travel in helical paths so as to be more likely to bombard the hydrogen (deuterium) flowing into chamber 23. Also, the electrical discharge tends to heat to high temperature the catalyst metal of plates 41, 42 and 51 as well as heating the anode member 31 which is formed of the catalyst metal.

Thus, as the hydrogen (deuterium) reaches the end of passageway 26 and moves outwardly adjacent the inner surface of plate 42 and, thence, through holes 43, 43', passing inwardly and out of hole 44, its tortuous path affords an ample opportunity for the gas to be absorbed and emitted from the catalyst metal of plates 42, 41. The catalytic effects of the platinum or palladium is to render the hydrogen gas nascent, i.e. break the hydrogen molecule into atoms. Thus, the evolving gas from hole 44 and from the surface of plate 41 is essentially atomic; however, these atoms, under normal conditions, would rapidly recombine to form molecules. Before many of the hydrogen atoms may recombine, they are struck by the electrons cascading in the ionizing zone thereby forming atomic ions, some of which are discharged through passageway 30 before they have had an opportunity to reunite.

It will be understood that both the ionized hydrogen atoms and ionized hydrogen molecules are directed through the passageway 30 and hence impinge against target 61. The bombardment of the tritium absorbed in target 61, by the ionized deuterium causes the target 61 to emit neutrons in all directions.

It has been determined that by use of my catalyst-electric discharge system, as described above, the atomic ions in the beam of a Penning ion source has been increased from about 5% to about 35% or more. Further, because the cathode poles 20 and 21 and the anode member 31 are formed of the same metal, namely platinum or palladium, there is no contamination of the catalyst due to sputtering of a dissimilar metal.

The heat generated by the glow discharge between anode member 31 and cathode poles 20 and 21 is effectively utilized by the catalyst in more effectively rendering the gas nascent.

It will also be seen that the cost of converting a conventional Penning ion source to the catalyst-electric discharge system of the present invention is very small. Indeed, utilizing my invention of incorporating the catalyst in the ionizing zone of the ion source renders a Penning ion source useful for many functions, heretofore thought to be impractical or requiring much heavier equipment. For example, the irradiation of oil wells for logging purposes may now be accomplished with much greater intensity using the present invention.

While it will be understood by those skilled in the art that there are a number of various types of ion sources and that these ion sources are useful for ionizing a wide variety of gases, the present disclosure, by way of illustration, describes only the Penning ion source illustrated in the drawing, operating in conjunction with a particular accelerator tube 60 and target 61 so as to produce neutrons from deuterons. Other targets and/or other gases may be employed in the present apparatus without departing from the inventive concept here illustrated.

It will be obvious to those skilled in the art that many variations may be made in the embodiments chosen for the purpose of illustrating the present invention without departing from the scope thereof as defined by the appended claims.

I claim:

1. In an ion source of the type having a chamber, an anode member within said chamber, a cathode member within said chamber, said cathode member having an inner surface in spaced relationship to said anode member, means for establishing an electrical discharge between said anode member and said cathode member, means for evacuating said chamber, and means for introducing hydrogen gas into said chamber, the combination wherein said anode member is formed from a noble metal selected from the group consisting of platinum, palladium and an alloy containing platinum or palladium, and including a plate of said noble metal covering said inner surface of said cathode member.

2. In an ion source of the type having a chamber, an anode member within said chamber, a pair of cathode members within said chamber, on opposite sides of said anode member, a magnet for creating a magnet field between said cathode members, said cathode members having inner surfaces in spaced relationship to said anode member, means for establishing an electrical discharge between said anode member and said cathode members, means for evacuating said chamber, and means for introducing hydrogen gas into said chamber, the combination wherein said anode member is formed from a noble metal selected from the group consisting of platinum, palladium and an alloy containing platinum or palladium, and including a plurality of plates of said noble metal covering said inner surfaces of said cathode members.

3. In an ion source of the type having a chamber, an anode member within said chamber, a pair of cathode members within said chamber, on opposite sides of said anode member, a magnet for creating a magnetic field between said cathode members, said cathode members having inner surfaces in spaced relationship to said anode member, means for establishing an electrical discharge between said anode member and said cathode members, means for evacuating said chamber, said cathode members being provided with passageways therethrough for communicating with said chamber, and means for introducing hydrogen gas into said chamber through one of said passageways, the combination wherein said anode member is formed from a noble metal selected from the group consisting of platinum, palladium and an alloy containing platinum or palladium, and including a plurality of plates of said noble metal covering said inner surfaces of said cathode members, one of said plates being adjacent the mouth of said one of said passageways and forming a tortuous path for said hydrogen as the same is introduced into said chamber, another of said plates being adjacent the mouth of the other of said passageways and having an opening aligned therewith.

4. In an ion source of the type having a chamber, an anode member within said chamber, a pair of cathode members within said chamber on opposite sides of said anode member, a magnet for creating a magnet field between said cathode members, said cathode members having inner surfaces in spaced relationship to said anode member, means for establishing an electrical discharge between said anode member and said cathode members, means for evacuating said chamber, said cathode members being provided with passageways therethrough for communicating with said chamber, and means for introducing hydrogen gas into said chamber through one of said passageways, the combination wherein said anode member is formed from a noble metal selected from the group consisting of platinum, palladium and an alloy containing platinum or palladium, and including a plurality of plates of said noble metal covering said inner surfaces of said cathode members, at least two of said plates being adjacent the mouth of said one of said passageways and having offset openings for forming a tortuous path for said hydrogen as the same is introduced into said chamber.

5. In an ion source of the type having a chamber, an anode member within said chamber, a pair of cathode members within said chamber on opposite sides of said anode member, a magnet for creating a magnet field between said cathode members, said cathode members having inner surfaces in spaced relationship to said anode

member, means for establishing an electrical discharge between said anode member and said cathode members, means for evacuating said chamber, said cathode members being provided with passageways therethrough for communicating with said chamber, and means for introducing hydrogen gas into said chamber through one of said passageways, the combination wherein said anode member is formed from a noble metal selected from the group consisting of platinum, palladium and an alloy containing platinum or palladium, and including a plurality of plates of said noble metal covering said inner surfaces of said cathode members, one of said plates covering the mouth of said one of said passageways and being sufficiently thin that said hydrogen passes therethrough as said hydrogen is introduced into said chamber.

6. In an ion source of the type having a chamber, an anode member, a cathode member within the chamber, a source of gas for feeding gas into said chamber and an evacuation system for creating a vacuum within said chamber, the combination therewith of a plurality of metal catalysts disposed within said chamber in positions to be heated upon discharge of an electric arc between said anode member and said cathode member, said plurality of catalysts being positioned so as to render said gas within said chamber nascent.

7. In an ion source of the type having a chamber, an anode member within said chamber, a pair of cathode members within said chamber on opposite sides of said anode member, a magnet for creating a magnetic field between said cathode members, said cathode members having inner surfaces in spaced relationship to said anode member, means for establishing an electrical discharge between said anode member and said cathode members, and means for evacuating said chamber, the combination

therewith of means for introducing hydrogen gas into said chamber through a passageway, and of a plate formed from a noble metal selected from a group consisting of platinum, palladium, and an alloy containing platinum or palladium closing the entry of said passageway into said chamber and positioned to be heated upon discharge of an electric arc between said anode member and said cathode members.

8. A process of ionizing a gas comprising the steps of catalytically rendering at least some of the gas nascent, partially ionizing the nascent gas while some of the nascent gas recombines, catalytically rendering at least some of the recombined nascent gas again nascent and ionizing the nascent recombined gas.

9. An ion source having two spaced apart catalytic cathodes, means for introducing a gas into the space between the cathodes, means for withdrawing an ionized gas from the space between the cathodes, a catalytic anode positioned in the space between the cathodes, and means for inducing a potential difference between the cathodes and the anode.

10. An ion source according to claim **9** wherein the cathode and anode catalysts are selected from the group consisting of platinum, palladium, or an alloy containing platinum or palladium.

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