Nov. 11, 1958 F. C. FORD ET AL 2,860,270

PULSED ION SOURCE

Filed Oct. 18, 1955

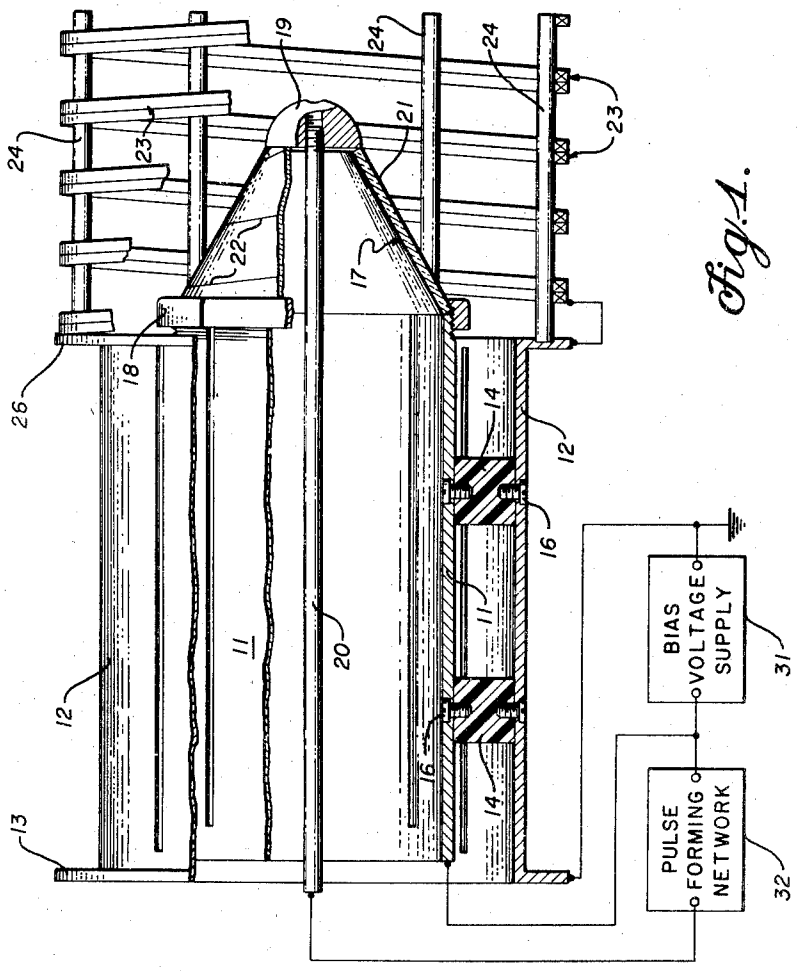

Fig. 1.

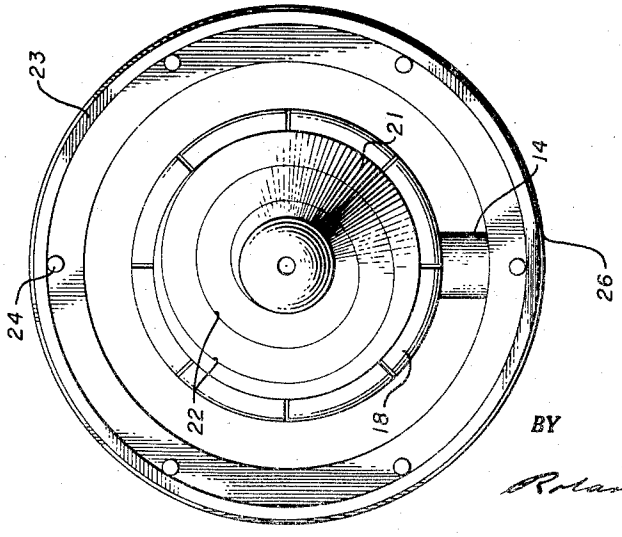

Fig. 2.

INVENTORS.
JAMES W. RUFF
SAMUEL G. ZIZZO
BUFORD COOK
FRANKLIN C. FORD

BY Roland A. Anderson
ATTORNEY.

United States Patent Office 2,860,270 Patented Nov. 11, 1958

2,860,270

PULSED ION SOURCE

Franklin C. Ford, Danville, and Samuel G. Zizzo, Buford Cook, and James W. Ruff, Livermore, Calif., assignors to the United States of America as represented by the United States Atomic Energy Commission

Application October 18, 1955, Serial No. 541,315

9 Claims. (Cl. 313—63)

The present invention relates to an ion source adapted for pulsed operation and producing copious quantities of ions with a particular ion egress geometry.

The ion source of this invention operates to ionize gas occluded in a metal by localized arc discharges. Certain metals have been found to readily absorb relatively large quantities of gas and by striking an arc between or across such metals having gas occluded therein, there are produced very large quantities of ions of the gas. By this means it is not necessary to provide a stream of gas to be ionized nor is there required a beam of ionizing particles. Additionally, substantially all gas leaving the metal is ionized so that vacuum difficulties in the source are minimized.

Many conventional ion sources produce a directed beam of ions wherein all ejected ions have substantially the same direction of propagation. The present invention, on the other hand, produces a burst of ions having velocity components axially of the source and radially outward therefrom about a complete circumference thereof. Various applications of ion beams are best suited by initial ion propagation radially about a point and axially therefrom, as, for example, in the apparatus disclosed in copending application Serial No. 443,447, filed July 14, 1954 by Richard F. Post. Ions are emitted from the source in a conical beam with the emitting surface the focus thereof and all the attendant advantages thereof attach hereto.

It is an object of the present invention to provide an improved occluded-gas ion source.

It is another object of the present invention to provide an ion source emitting ions therefrom with radial and axial velocity components.

It is a further object of the present invention to provide a pulsed ion source having improved ion emission geometry.

It is yet another object of the present invention to provide an ion source having a conical ion generation surface and propagating ions therefrom in a diverging cone.

Numerous other possible objects and advantages of the present invention will become apparent to those skilled in the art from the following description and appended claims together with the accompanying drawing wherein:

Figure 1 is a longitudinal view of an ion source in accordance with the present invention with portions broken away as indicated and including associated electrical circuitry; and

Figure 2 is an end view of the ion source as viewed from the right of Fig. 1.

Considering now the structural details of the illustrated embodiment of the invention and referring to the drawings, there are provided a pair of longitudinally slotted cylinders **11** and **12** with the latter disposed concentrically about the former. The outer cylinder **12** is adapted for mounting upon support means as by a flange **13** about the base end thereof and the relative disposition of cylinders is maintained by a plurality of like insulating blocks

14 disposed between the cylinders and secured thereto as by bolts **16** threaded into the blocks through the cylinder walls. In the event that the outer cylinder **12** is to be mounted upon a plate or the like at the outer or left end thereof, the inner cylinder **11** has the outer or left end thereof displaced to the right of the flanged end of the cylinder **12** so as not to contact the plate, inasmuch as the cylinders are adapted to have a potential difference impressed therebetween.

A conical member **17** is disposed in closing relation to one end of the inner cylinder **11** and may be fixed in position by a clamp ring **18** fitting about the large end of the member **17** and threaded onto the end of the cylinder **11**. The clamp ring **18** is longitudinally grooved to limit eddy currents therein. This conical member **17** is formed of an insulating material, such as glass or the like, and has an opening in the small outer end thereof which is closed by a semispherical end plug **19**. A central rod **20** formed of electrically conducting material extends through the cylinder **11** along the axis thereof with one end threaded into the end plug **19** and the other end adapted for insulated support as by means of an insulator through a face plate (not shown) upon which the source may be mounted at the base end thereof.

The conical member **17** has a thin metal coating **21** deposited evenly over the outer surface thereof as by vacuum evaporation, and a metal such as titanium having good gas loading characteristics is employed for this coating. The coating is then scribed or scored to form a groove or grooves **22** on the metalized conical surface. Preferably this scribing forms a helical groove thereby producing a metal ribbon extending about the conical member from the inner cylinder **11** to the end plug **19**. The groove or grooves **22** provide arc paths across the widths thereof for the ionization of gas occluded in the metal covering, as set out below. The covering **21** is loaded with a gas to be ionized, and for example, deuterium may be employed as the gas to provide a proton source.

Ions produced by the present source are accelerated substantially normal to the surface of the conical member **17**, and this is accomplished by means of ion accelerating structure including a generally cylindrical winding **23** disposed coaxially with the cylinders **11** and **12** and extending from the inner end thereof about and beyond the conical member. Physical support for the winding **23** may be provided by a plurality of rods **24** secured to a flange **26** about the inner end of the outer cylinder **12** and the rods extend axially of the cylinder beyond the conical member **17** and end plug **19** thereof. The winding **23** is wound noninductively by the inclusion of winding turns in opposite directions along the winding, in order that no current flow may be induced therein by the passage of ions or electrons thereby. Also the winding **23** is wound with openings therein, as illustrated, to provide ion egress apertures whereby ions attracted from the conical member **17** pass through the winding. The function of the winding **23** is the acceleration of ions out of the source and this is attained by a potential impressed upon the winding, not by current flow therethrough, as noted below.

Electrical energization of the above-described elements of the invention is accomplished by a bias voltage supply **31** connected between the outer cylinder **12** which is grounded and the inner cylinder **11**. The bias voltage supply provides a direct current voltage for impression between the cylinders with the inner cylinder being maintain at a positive potential with respect to the outer. The winding **23** is electrically connected to the outer cylinder so as to be biased negatively with respect to the inner cylinder and attached conical member **17**. Ion production is accomplished by the impression of high

current pulses across the cone surface 21 and a pulse forming network and supply 32 is connected between the inner cylinder 11 and the central rod 20 joined to the end plug 19.

Considering now the operation of the improved source of the present invention, it will be seen that the bias voltage supply maintains the open winding 23 at a negative potential with respect to the inner cylinder 11 and attached cone 17 so as to establish an electric field attracting ions from the cone toward the winding. There are applied across the metal coating 21 on the cone from end plug 19 to inner cylinder 11 high current pulses which produce localized arcing at a plurality of points across the groove 22 on the metal coating. This arcing over the outer metalized cone surface ionizes gas occluded in the metal and these ions fall through the electric attracting field, above noted, to accelerate toward the accelerating winding and pass through the openings therein. An extremely large quantity of ions are formed on the cone and accelerated therefrom during each pulsed energization thereof and the direction of propagation of ions from the source is generally normal to the conical surface so as to produce a pulsed conically diverging ion beam of high current. Eddy currents on the cylinders are minimized by the slots therein. The noninductive feature of the winding 23 employed to accelerate ions from the source is advantageous in that no net current is induced therein by the passing ions to vary the accelerating field thereof as would otherwise be the case. Additionally, as the ion source is adapted for use with apparatus employing magnetic fields, and particularly time-varying magnetic fields, same would induce currents in solid ion accelerating structure or conventional windings, but do not do so in the winding of the present invention. Such induced currents in the accelerating structure would locally vary the potential thereof to produce uneven ion ejection; however, the present invention produces a uniform cone of ions emitted from the source.

What is claimed is:

1. An ion source comprising a conical member having a metalized outer surface with grooves therein, said metal surface having gas occluded therein and being adapted for electrical pulsed energization to establish arcing across said grooves whereby ions are formed of said occluded gas, and a winding about said cone having openings therein and adapted for maintenance at a potential that is negative with respect to said cone for attracting ions therefrom and ejecting ions from the source in a diverging conical beam.

2. An ion source comprising a conical member having a gas loaded outer surface producing ions upon electrical discharge thereover, and ion accelerating means establishing an electrical field gradient substantially normal to the surface of said conical member thereby attracting ions from the entire surface thereof and generally normal thereto for producing a conical diverging ion beam.

3. An ion source comprising a conical member having an electrically responsive outer surface for producing ions therefrom, and a noninductive winding disposed axially of said conical member and about same with uniform openings therethrough evenly disposed over the surface thereof and adapted to be maintained at a negative potential with respect to said conical member for accelerating ions therefrom in a uniform conically diverging ion beam normal to the outer surface of said cone.

4. An ion source comprising a cone having an outer surface formed of a metal having an affinity for gas and being loaded with gas to be ionized, said cone having grooves formed on the outer metal surface thereof, means for applying high current pulses between ends of said cone whereby arcing occurs across the grooves thereon to ionize gas occluded therein, a cylindrical winding disposed axially about said cone and having a plurality of openings radially therethrough, and means maintaining said winding at a negative potential with respect to said cone whereby ions are ejected through said winding in a conically diverging ion beam.

5. An ion source as claimed in claim 4 further defined by said winding including an equal number of turns of wire in opposite directions along the length thereof whereby said winding is noninductive and maintains a constant potential throughout during ion ejection.

6. An ion source comprising an insulating cone having a thin metal coating upon the outer surface thereof, said coating including a metal having an affinity for absorbing gas and having a gas to be ionized occluded therein, said metal coating further having grooves therethrough about the cone, means applying high current pulses between ends of said cone for producing arcing across the grooves in the coating thereof whereby gas occluded therein is ionized, an open winding disposed about said cone, and means impressing a potential between said cone and winding for establishing an ion accelerating electric field whereby ions are ejected through said winding.

7. An ion source comprising a pair of concentric electrically conducting cylinders, an insulating cone mounted with the base thereof upon the end of the inner cylinder and axially thereof, a thin metal coating disposed over the outer surface of said cone and having at least one groove therethrough extending circumferentially thereabout a plurality of times, said coating being formed of a metal having an affinity for gas and said coating electrically contacting said inner cylinder at the base of the cone, an electrically conducting rod disposed axially of said cylinders and cone and electrically connected to said coating at the apex of said cone, a gas to be ionized occluded in said coating, means producing high current pulses of electrical energization connected between said rod and inner cylinder for producing arcing across the groove in said coating whereby occluded gas is ionized, a cylindrical noninductive winding mounted on the end of said outer cylinder enveloping said cone and electrically connected to said outer cylinder, said winding having a plurality of openings therethrough for ion passage, and bias power supply means connected between said inner and outer cylinders for establishing a potential difference between said winding and the coating on said cone whereby ions formed at the latter are accelerated through said winding.

8. An ion source comprising a member having a conducting surface formed of a metal with a gas occluded therein for ionization and narrow nonconducting portions thereon dividing said conducting surface, means applying pulsed high voltage across said conducting surface for producing a discharge across same including the nonconducting portions thereof whereby ions are formed at said surface, and ion accelerating means removing ions from the vicinity of said surface.

9. An ion source as defined in claim 8 further characterized by said conducting surface having the nonconducting portions thereon disposed to define an elongated electrical conductor with closely spaced sections and means connecting said high voltage means between ends of said conductor.

References Cited in the file of this patent

UNITED STATES PATENTS

2,786,143 Ruby et al. ---------- Mar. 19, 1957