

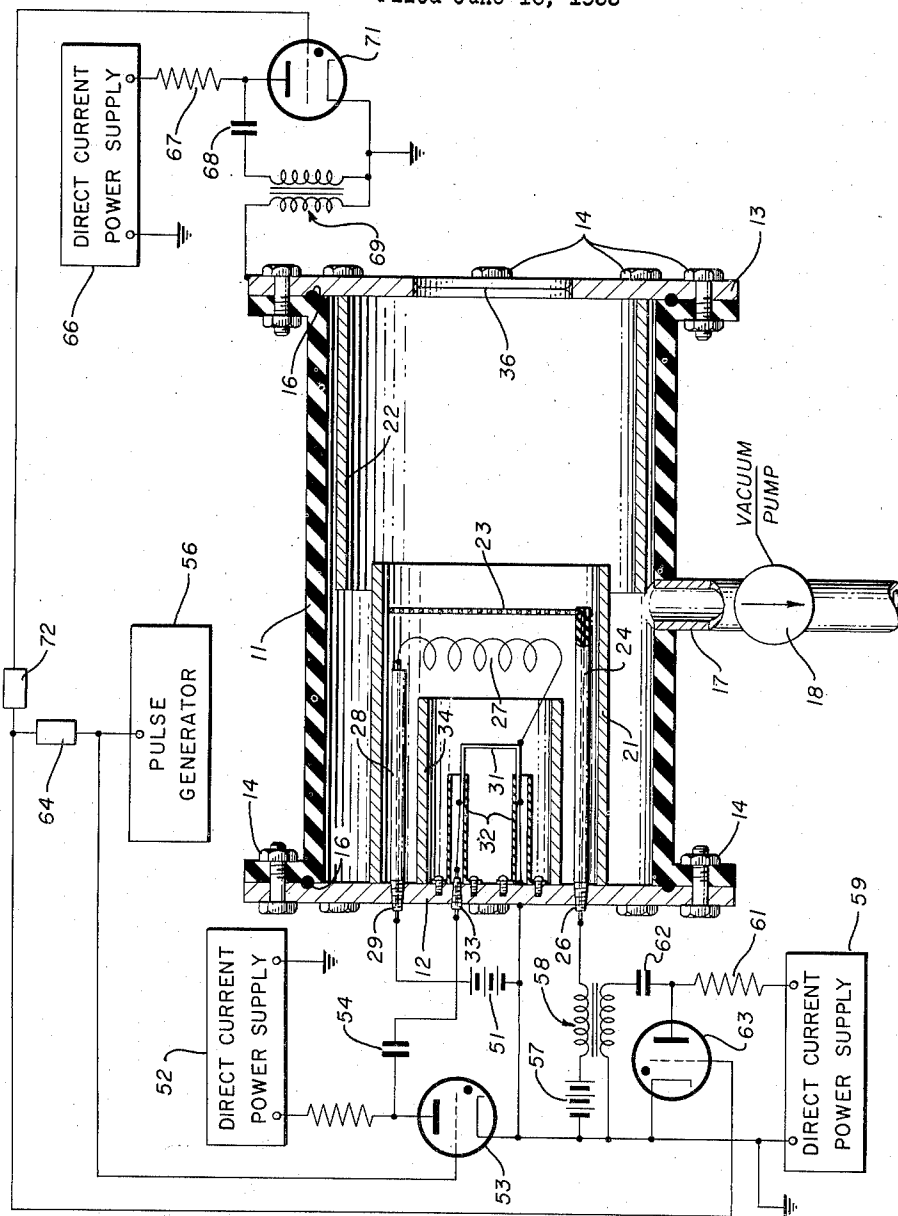
Oct. 14, 1958

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2,856,532

PULSED ION SOURCE

Filed June 16, 1955



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PULSED ION SOURCE

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Application June 16, 1955, Serial No. 516,056

6 Claims. (Cl. 250—49.5)

The present invention relates to an improved ion source and, more particularly, to an ion source adapted to produce a pulsed beam of ions.

Pulsed ion sources that employ a constant stream of volatilized source material experience various difficulties in handling of the source material in that an overly large quantity thereof is expended without a proportionate ion current and there is produced contamination of the source and attached apparatus utilizing the ion beam by quantities of un-ionized source material liberated between pulses of source energization. Attempts to supply from such as a bottle of volatilized source material pulses of gas to be ionized have proven generally unsatisfactory because of the difficulty in properly and accurately timing the flow of gas.

The present invention satisfies the criteria for pulsed ion sources without the difficulties attendant other known pulsed ion sources and in addition provides a source having a very long life by the accomplishment of the following objects:

It is an object of the present invention to provide an improved pulsed ion source having a long term source material supply.

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

It is another object of the present invention to provide an improved pulsed ion source having ionizing means and a gas supply occluded in an auxiliary filament not comprising one of the ionizing electrodes.

Numerous other more specific objects and advantages of the invention will become apparent to those skilled in the art from the following description of a preferred embodiment of the invention taken together with the accompanying drawing wherein the sole figure is a schematic sectional view of the ion source together with appropriate associated electrical circuitry.

Considering the structural details of the illustrated embodiment of the invention and referring to the drawing, the source proper will be seen to be contained in an insulating cylindrical shell 11 having a ground plate 12 secured thereto in closing relation to one end and an end plate 13 secured in closing relation to the other cylindrical end. Joinder of the shell 11 and plates 12 and 13 thereto may be facilitated by the provision of flanges about the cylindrical shell ends against which the plates 12 and 13 are tightly drawn as by bolts 14 and these joints are made vacuum tight by the insertion of suitable gaskets 16 therein. A pipe 17 is secured to the shell 11 in sealed communication with the interior thereof and is connected to evacuation means, such as one or more vacuum pumps 18 whereby the shell may be continuously evacuated.

Within the cylinder shell there is disposed a first cylindrical electrode 21 secured to the ground plate 12 and extending coaxially of the shell toward the opposite shell end past the center of the shell. A similar cylindrical electrode 22 of greater diameter than the first cylinder 21

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is mounted upon the inner surface of the end plate 13 and extends coaxially of the shell 11 toward the ground plate in overlapping relation to the free end of the first cylinder 21 and out of contact therewith. Within the cylinder 21 and adjacent the open end thereof is disposed a grid electrode 23 having an open mesh structure and disposed in a plane normal to the axis of the cylinder 21. This electrode is mounted in insulated relation to the ground plate 12 and cylinder 21 as by means of one or more insulating standards 24 affixed to the ground plate in rigid relation thereto. A lead-through insulator 26 in the ground plate extends an electrical lead from the grid 23 to the exterior of the shell for connection to suitable circuitry described below.

An electron emissive filament 27 is also provided within the shell 11 in spaced relation to the grid 23 toward the ground plate 12 therefrom, and this filament 27 may take the form of a coil or of a flat-wound spiral of electron emissive conductor. The filament is mounted in fixed position by one or more insulating supports 28 extending longitudinally inward of the shell from the ground plate 12 with a lead-through insulator 29 extending through the ground plate and providing an external electrical terminal connected by a lead through a support 28 to the filament 27, the other end of which is grounded.

A gas source is provided within the shell for the ionizing means therein and this gas supply includes a wire or bar of metal 31 characterized by an ability to absorb or occlude large amounts of gas. Where hydrogen or isotopes thereof is to be ionized metals such as titanium, tantalum, palladium, and zirconium, for example, have been found to be suitable. The wire 31 is prepared by outgassing at high temperatures to remove random gas therefrom followed by exposure of the metal to the source gas for absorption at high temperatures and a subsequent slow cooling of the metal with a resultant retention by the metal of a large quantity of source gas. The wire 31 is supported adjacent the filament 27 and separated from the grid 23 thereby between a pair of insulators 32 extending inward of the shell from the ground plate 12. One end of the wire 31 is grounded as by connection to the ground plate 12 and the other wire end is electrically connected through an insulator 32 to a lead-through insulator 33 in the plate 12 for connection externally of the shell to appropriate energizing means. The gas source is laterally surrounded by a metal cylindrical shield 34 mounted upon the ground plate 12 and extending beyond the filament interiorly of the shell.

Ions formed within the above-described source may be utilized therein or may be employed exteriorly of the shell 11 and, in the latter instance, ion egress means such as an aperture or window 36 is provided in the end plate 13 in axial alignment with the grid 23 and filament 27.

Energization of the above-described elements of the ion source may be accomplished by means of appropriate circuitry disposed exteriorly of the source proper. There is illustrated in the drawing a suitable circuit including a power supply 51 connected between the filament terminal 29 and ground for passing a heating current through the filament to heat same to incandescence whereby electrons are thermally emitted therefrom. Pulsed energization of the gas source is accomplished by a direct current power supply 52 which has the negative terminal thereof grounded and the positive terminal connected through a resistor to the anode of a grounded gaseous discharge tube 53. The anode of tube 53 is connected to one side of a capacitor 54, the other side of which is joined to the terminal 33, and the control electrode of the tube 53 is connected to the output of a pulse generator 56. The tube 53 is normally nonconducting and conducts in response to voltage pulses impressed

upon the tube control electrode from the pulse generator 56 so that the capacitor 54 discharges through the gas supply member 31 to instantaneously heat same and drive off vapor or gas occluded therein. The capacitor 54 recharges during nonconductance of the tube 53 and discharges through the gas supply member 31 each time the tube fires.

The control electrode or grid 23 of the source is also connected for pulsed energization with a grounded power supply 57 supplying a steady positive grid bias and pulsed signals being applied thereto by means of the secondary winding of a transformer 58 connected between the grid terminal 26 and the positive terminal of the power supply 57. A direct current power supply 59 has the positive terminal connected through a dropping resistor 61 to one side of a capacitor 62 that has its other side grounded through the primary winding of the transformer 58. The capacitor 62 is discharged through the transformer by means of a gaseous discharge tube 63 having a grounded cathode and an anode connected to the power supply side of the capacitor. The tube 63 is normally nonconducting so that the capacitor 62 is charged from the power supply 59 through the resistor 61 and the tube is triggered by pulsed signals applied to the control electrode of the tube from the pulse generator 56 through a delay line 64 having a predetermined time delay. Conduction of the tube 63 discharges the capacitor 62 through the primary winding of the transformer 58 so that there is induced a voltage in the secondary winding thereof to supply an instantaneous negative grid voltage.

The end wall 13 and electrode 22 attached thereto are likewise energized from a grounded direct current power supply 66 having a positive terminal connected through a dropping resistor 67 to one side of a capacitor 68 that has the other side thereof grounded through the primary winding of a transformer 69. The secondary winding of the transformer 69 is grounded at one end and connected at the other to the ion source end wall 13. The capacitor 68 is discharged by means of a gaseous electric discharge tube 71 having a grounded cathode and an anode connected to the capacitor 68 on the opposite side thereof from the transformer 69. The tube 71 is normally nonconducting, during which time the capacitor 68 charges and remains charged, and a positive signal on the control electrode of the tube triggers same to discharge the capacitor 68 and applies a negative voltage pulse through the transformer 69 to the end plate 13. The tube control electrode is connected through a delay line 72 to the delay line 64 attached to the output of the pulse generator 56 so that the pulse to tube 71 is delayed a predetermined period beyond the signal applied to the grid 23 of the ion source.

Considering now the operation of the improved ion source of the present invention and assuming the shell 11 to be evacuated, the power supply 51 will be seen to provide a current flow through the filament 27 whereby the latter is maintained electron emissive. The power supply 57 maintains the grid electrode 23 at a positive potential with respect to ground and thus also with respect to the filament 27 so that electrons are attracted from the filament toward the grid to form a continuous electron discharge. As the remainder of the source including the cylinders 21 and 22 are normally at ground potential this electron discharge extends in concentrated form only in the general region of the filament-grid space.

Pulsed production of ions within the source is accomplished by actuating the pulse generator 56 to produce a voltage pulse which is applied to the control electrode of the discharge tube 53 to cause conduction of this tube. As the tube 53 conducts, the capacitor 54 discharges to apply a current pulse through the terminal 33 to the gas source member 31 whereby same is momentarily heated to drive off gas or vapor occluded therein. As

the capacitor 54 discharges the anode potential of the tube 53 falls so that the tube is rendered nonconducting until the next triggering pulse at the control electrode. The gas or vapor driven off the member 31 drifts into the filament-grid space by virtue of the vacuum pump causing a progressively better vacuum from the ends to the center of the shell 11 and this gas is ionized by the electron discharge from the filament to produce an arc discharge. The signal from the pulse generator which was applied to the tube 53 is also applied to trigger the tube 63 after a predetermined delay in line 64 so that the tube 63 fires and applies a signal across the transformer 58 that appears as a negative signal in the secondary circuit thereof to momentarily drive the grid electrode 23 negative with respect to ground. As the capacitor 62 discharges, the tube 63 is rendered nonconducting; however, the negative grid pulse which follows ionization of the gas in the electron discharge attracts positive ions from the arc and accelerates same to the right in the drawing through the grid 23.

Similarly the pulse signal from generator 56 is likewise applied to the tube 71 through the delay lines 64 and 72 so as to render the tube 71 conducting at a time following attraction of ions from the arc. As the tube 71 conducts it passes a pulse signal through the transformer 69 which appears as a negative pulsed voltage at the cylinder 22 and end wall 13 whereby ions passing through the grid electrode 23 are subjected to the attractive force thereof and forcibly driven through the cylinder 22 toward the end wall 13 where they may pass through the window 36 or be otherwise employed as desired.

What is claimed is:

1. An ion source comprising an electron emissive filament energized for electron emission, a grid electrode disposed in spaced relation to said filament and normally maintained at a positive potential with respect thereto for establishing an electron discharge in a zone between said filament and said grid, a member having a gas occluded therein disposed adjacent said discharge zone and out of contact therewith, said member being adapted for pulsed heating to drive pulses of gas therefrom into said discharge zone where same is ionized, and said grid being adapted for pulsed energization to establish a positive electric field attracting ions from said zone through said grid.
2. An ion source comprising an electron emissive filament, a grid disposed adjacent said filament, a power supply maintaining said grid normally positive with respect to said filament whereby electron discharge occurs between said filament and grid, an electrically conducting member having gas occluded therein disposed immediately adjacent said filament on the opposite side thereof from said grid and adapted for electric pulsed heating to drive gas therefrom, means directing said gas into said discharge for ionizing same, and means electrically pulsing said grid at a negative potential for attracting ions from said discharge.
3. An ion source as claimed in claim 2 further defined by means controlling pulsed heating of said member and negative energization of said grid for delaying the latter a predetermined time following the former whereby said grid attracts ions only during the period same are formed in said discharge.
4. An ion source comprising an electron emissive filament energized to emit electrons, a grid electrode spaced from said filament and normally maintained at a positive potential with respect thereto whereby an electron discharge occurs therebetween, a member having gas occluded therein disposed adjacent said discharge and out of contact therewith, means for passing a pulsed heating current through said member for driving bursts of gas therefrom, means directing said gas into said discharge for ionization thereof, means electrically pulsing said grid a predetermined time following heating of said

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member for establishing a pulsed electric field about said grid attracting ions from said discharge, and an electrode disposed on the opposite side of said grid from said filament and electrically pulsed a predetermined time following grid pulsing for attracting ions from said grid.

5. An ion source for producing a pulsed beam of ions comprising means establishing a substantially continuous electron discharge through an evacuated discharge zone, an electrically conducting member containing gas occluded therein disposed adjacent said zone exteriorly thereof, means electrically energizing said conducting member in a pulsed fashion to heat same and drive therefrom bursts of gas which drift into said zone for ionization, and electrode means periodically energized to attract ions from said zone.

6. An ion source comprising an envelope having an evacuation opening therein, means within said envelope energized to establish a substantially constant electron

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discharge through a predetermined zone, an electrically conducting occluded gas member disposed adjacent said zone on the opposite side thereof from said evacuation opening, means electrically pulsing said occluded gas member for driving bursts of gas therefrom which drift toward said evacuation opening into said discharge zone for ionization therein, and electrode means withdrawing pulses of ions from said zone.

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